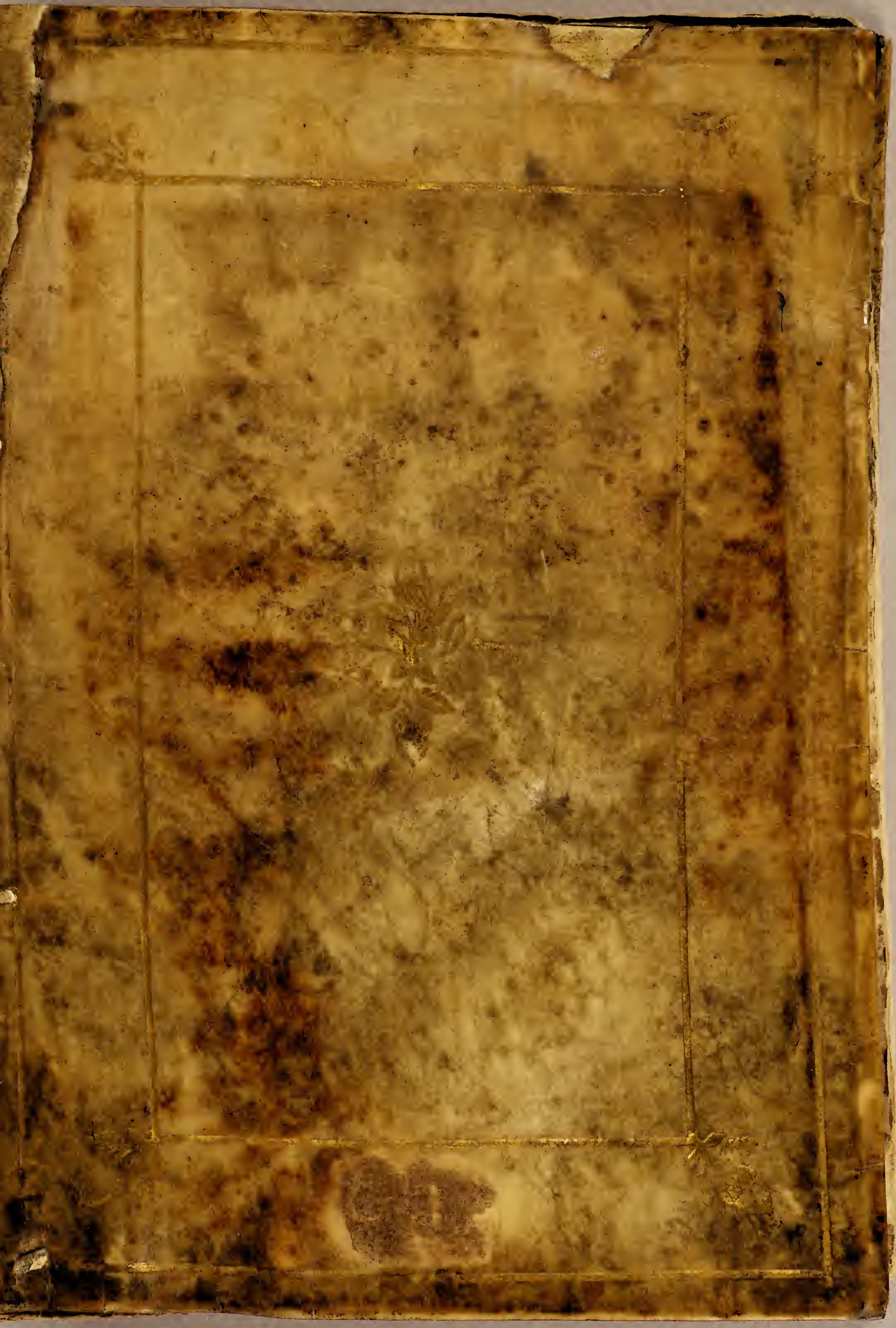

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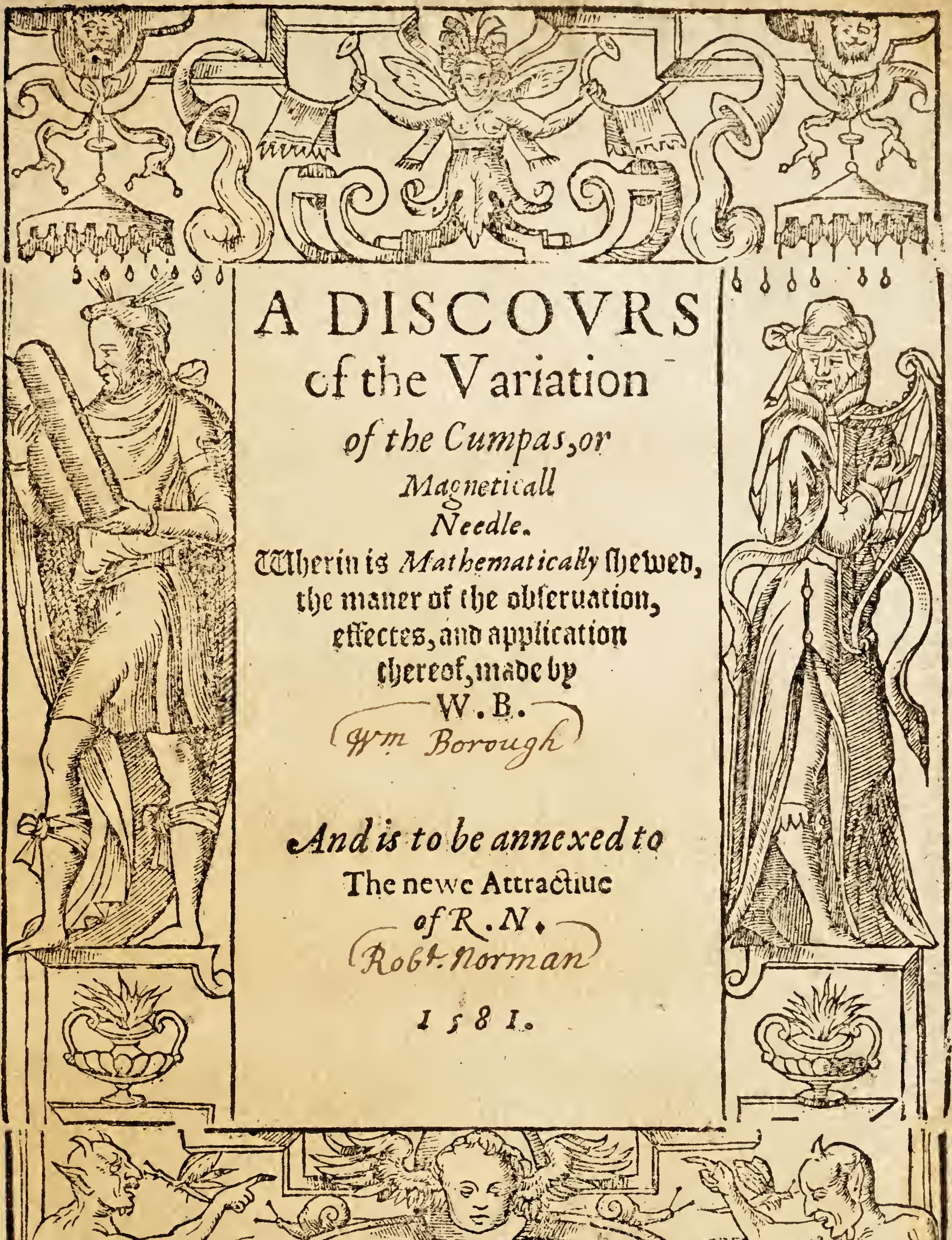

A DISCOVRS of the Variation of the Cumpas, or Magneticall Needle.

Wherin is *Mathematically* ſhewed,
the maner of the obſeruation,
effectes, and application
thereof, made by
W. B.
(Wm Borough)

And is to be annexed to
The newe Attractiue
of R. N.
(Robt. Norman)

1581.

May 6th 1822
1581
241 years old

To the Trauelers, Seamen, and *Mariners of Englande.*

HAuyng of late (gentle reader) receiued from the expert Artificer Ro. Norman, his booke intituled The newe Attractiue (who of the great good will, and affection he beareth, hath attributed in his dedication, that, whiche I acknowledge not to bee dewe) in the whiche amongeſt other diuers vertues and properties of the Magnes or Lodeſtone, he intreateth of the declinyng of the Needle touched therewith from the plaine of the Horizon, (a matter neuer before found, or written of by any). For the further behoofe and benefite of all traueilers and Seamen, I tooke occaſion to inlarge the ſame with this diſcourſe of the variation of the Compaſſe, wherein I haue handled the whole varietie of that ſubiect, bothe Practically, and Mathimatically, to the ende I might partly ſatiſfie bothe the vulgar, and alſo the learned ſort. For, knowyng the variatiō of the Cumpaſſe to bee the cauſe of many errours and imperfections in Nauigation, and perceiuyng that all thoſe that haue as yet gone about to giue rules in that *arte,haue left this(beyng a principall poinct,and euẽ the grounde of all the reſte)vntouched,or at leaſt ſo ſleightly handled the ſame, that little or no benefit could be gathred therby: I haue here ſet doune the ſũdrie waies to obſerue the ſame at all tymes & places, that the inconuenience beyng knowne,might be conſidered of,and auoided. VVherein,although my cheefeſt intent hath been to pleaſure thoſe that ſhall haue occaſion to put the thyng in practice by their owne trauaile and experience,yet becauſe ſome of the rules are deducted from the fountaines of the Mathematicall Sciences, and wrought by the doctrine of Sines and Triangles, whiche maie ſeeme ſtrange in our Engliſhe tonge,& wherwith fewe Seamen are yet acquainted, I maie ſeem to haue miſſed of my firſt good meanyng, but I would wiſhe them to chuſe that whiche is plain, and conformable to their capacities, and make their profite thereof,and for the reſte vnderſtande,that of ſuche obſeruations as thei them ſelues can not preſently applie to the purpoſe, by others that are throughly inſtructed in theſe Mathematicall ſupputations, or by them ſelues when thei ſhall attaine to the knowledge therof,maie be inferred ſuche effectuall matter as is by theſe rules and preceptes promiſed. VVherefore I would haue all Seamen to vſe ſuche diligence in* their trauailes, that no oportunitie be omitted, when, or where any obſeruation maie be made, either for the variation, or latitude of places, or of any other neceſſarie poincte incident to Nauigation, and thereof to keepe continuall notes & memoriall. For theſe obſeruations, there needeth not many troubleſome Inſtrumentes, onely for the variation, the newe Inſtrument in the ende of this treatiſe I preferre before all other. And for eleuations, a plaine Aſtrolabe exactly made, and a croſſe ſtaffe, are ſufficient. (The Globe were alſo a verie good and neceſſarie Inſtrument for beſides many pleaſaunt concluſions that maie be tried by it, it doeth lighten verie muche the conceiptes, for vnderſtandyng diuers important poinctes, but it is too troubleſome [or otherwiſe not fit for euery Mariner] to be caried to the Sea). Vnto the whiche maie bee added the Topographicall Inſtrument, for taking of diſtances, and making deſcriptions vpon the land. VVith theſe Inſtrumentes, and the ſailyng Cumpaſſe and Marine plat, (whiche are alwaies to be vnderſtoode the principall, and moſte neceſſarie Inſtrumentes for Nauigation, for by them onely any voiage maie bee made, but without them no Nauigation can bee performed.) the whole worlde maie bee traueled, diſcouered, & deſcribed. Theſe are ſufficient for a per-

fecte Mariner, and more then theſe were ſuperfluous, onely the runnyng glaſſes, leades, lines, and ſuche like appendances of the other excepted.

But to haue all theſe Inſtruments, and not to vnderſtande the groundes how to vſe them, were a great vanitie. Therefore I wiſhe all Seamen & Trauellers, that deſire to bee cunnyng in their profeſſion, firſte to ſeeke knowledge in Arithmetik & Geometrie, whiche are the groundes of all Science and certaine artes, of the whiche there is written in our Engliſhe tõgue, ſufficient for an induſtrious and willyng minde to attain to greate perfection, whereby he maie not onely iudge of Inſtrumentes, Rules, and preceptes giuen by other, but alſo bee able to correcte them, and to deuiſe newe of hym ſelf. And this not onely in Nauigation, but in all Mechanicall Sciences. As by the ſtudious practiſe and exerciſe in theſe artes, haue attained to rare and ſinguler knowledge: In Architecture, Vitriuuius the Romaine: In paintyng that famous Germaine Albertus Durerus: And in buildyng of Shippes, Matthewe Baker our countrieman: And others in other faculties as thei haue been moſte ſkilfull herein, ſo haue thei excelled. Hauyng theſe helpes and groundes with the Inſtrumentes before ſpecified, a Mariner maie bee able to make deſcription in platt of the coa-

ſtes and Countries,and of the Banckes , Rockes, and Sholdes in the Sea , with the deapthes and other neceſſarie notes obſerued in his owne trauailes particularly, & effectually accordyng to the truthe,(whiche is the cheefeſt parte required in a perfect Mariner.) And not be alwaies tied to the reportes of other,or to the Portugale,or Spaniſhe Marine platts,whiche are made by the Cardmakers of thoſe Countries,men that are no trauelers them ſelues,but doe all thinges therin,by information, and vppon the credite of others, whiche onely committ to memorie the forme and maner of the Sea coaſtes,with makyng ſome fewe notes of the liyng of one place from an other,whiche can neuer bee ſo perfecte as the deſcriptions that are made vppon the preſent ſight and vewe of places,albeeit he be neuer ſo ſkilfull and cunnyng , that ſhall ſo cary the ſame by memorie , how muche leſſe then by the vnſkilfull. By this meanes the Cardmakers ſet doune thei knowe not what: as maie appeare by the deſcriptions of their owne coaſtes,whiche are verie groſſely and vnperfectly dooen,whereas the Marine plattes ought to bee deſcribed by ſuche as can giue reaſon,and ſhewe obſeruation of euery particularitie contained in the ſame,aſwell for the latitude of places,as the liyng by the Compaſſe of the Capes,Headlandes,Poin-

ctes, Ilandes, Baies, Rockes, Sholdes &c. one from an other, and the diſtances betweene them. The errors of thoſe deſcriptions, I maie not attribute to the Cardmakers, but to the vnſkilfull Seamen of thoſe countries, for if thei were otherwiſe, as thei haue been accompted the moſte ſkilfull of the worlde, thoſe errors could not haue cōtinued as thei doe: true it is that for their great trauailes, thei haue been worthely famous aboue all other nations, till now at length our Countrieman Sir Frācis Drake for valorous attempt, prudent proceadyng, & fortunate performyng his voiage about the worlde, is not onely become equall to any of them, but in fame farre ſurmounteth them all. But thoſe Cardmakers, and all other that collecte and gather Hydrographical, and Geographicall deſcriptions of other mennes trauailes or reportes: as their paines maie bee greate, and deſerue due commendation, ſo their doynges maie bryng commoditie diuerſely. And in this behalf Abrahamus Ortelius in his Theatrum, hath deſerued immortall praiſe, for collectyng together, and reducing into one cōmodious volume, the diuers plattes and deſcriptiōs, made by diuers and ſundrie men. But amongſt all thoſe that haue made Geographicall deſcriptions, I can not a little maruaile at Guilielmus Poſtellus, who beeyng a famous learned

ned man, a greate traueiler and Coſmographer, and Deane of the Kynges Profeſſors in the Vniuerſitie of Paris, in his vniuerſall Mappe. Anno 1580. beſides that it is generally handeled after ſuche a groſſe and confuſed maner, that it might ſeeme rather to haue come from ſome rude vnſkilfull, then from hym ſo famous a Doctor; hath alſo in the imagined Countries aboute the North Pole, ſo corrupted it with his fonde dreames, and fantaſticall inſcriptions, attributyng to thoſe ſuppoſed landes, diuers people, as the Georgians and Hyperborians, and aſſignyng there to be the higheſt hilles of the worlde, and the people dwellyng on thẽ, to haue the continuall light of the Sunne; Sueta Zemlia founde by the Engliſhemen, An. 1550. the holie Lande, the place of the cheefeſt felicitie, the Hyperborean feeldes, and therefore the felicitie of the Moluccas, with many other ridiculous abſurdities: That by the groſſe errors of this learned man in theſe matters, I am taught, that what ſo euer fame goeth, or opinion is conceiued of any man for profound learnyng, and ſmothe deliueryng of their conceiptes, or what ſo euer greate promiſes are by them ſelues made in theſe artes, to iudge of them accordyng to the woorkes that come from them, and not otherwiſe to bee deceiued.

The Preface.

For auoidyng prolixitie in this my Preface to ſo ſmal a volume, I referre the gẽtle reader, to the worke it ſelf. Yet by the waie it ſhall not bee a miſſe, that I commende vnto you, the table of the Sunnes declination (or Regiment) made by R.N. which is calculated for the preſent tyme, and differeth not from the truth in any place aboue one minute, wheras in all other hetherto made and extant, there are great errors. Therfore, ſuche as otherwiſe can not from tyme to tyme calculate their declinations, accordyng to the place of the Sunne to bee giuen by the Ephemerides, and table of declination of Reinholdus maie boldly vſe this Regiment for 20. yeres without any ſenſible errour. And ſo wiſhyng my trauailes in this treaſe maie doe ſuche good as I ment, I commit the ſame to your gentle conſtructions, and your ſelues to the Almightie. At Limehouſe the 26. of September. Anno 1581.

VVilliam Borough.

A Table of the Chapters contayned in the treatis.

¶ The firſt Chapter.

OF the Variation of the Cumpas, or magneticall Needle.

¶ The ſecond Chapter.

The maner how to vſe the Inſtrument of Variation.

¶ The third Chapter.

How to finde the Variation of the Cumpas or Needle at any place, the eleuation of the Pole, and ſituation of the meridian vnknowne.

¶ The fowerth Chapter.

The eleuation of the Pole, and place of the Sunne giuen, how vpon the Globe, to finde the Variation of the Needle, by any one obſeruation, either in fornoone or afternoone.

¶ The fift Chapter.

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¶ The ſixt Chapter.

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The ſeuenth Chapter.

To finde the eleuation of the Pole, ſituation of the meri-

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¶ The eight Chapter.

Of the Pole of the Magnes.

¶ The ninth Chapter.

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Of the inconueniences and defects in ſaylyng, and in deſcription of Countries, cauſed by the variation of the Cumpas.

¶ The eleuenth Chapter.

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Of the application of the Variation, to the vſe of Nauigation.

¶ Of the Variation of the Cumpas or *Magneticall Needle.*

Chapter I.

THE Variation of the Needle of Cumpas, is properly the ark of the Horizō contained betwẽen the true meridiā of any place and the magneticall meridian of the ſame, and is denominated to bee Eſterly or Weſterly, accordyng to the poſition of the magneticall meridian to the Eſtwards or Weſtwards of the true meridian: And may be accompted either from the North parte, or the South parte thereof, but vppon oppoſit points it hath contrary denominations.

The magneticall meridian is to bee vnderſtood a greate circle paſſyng by the Zenith and the Pole of the Magnes, deuidyng the Horizon into two equall parts croſſyng the ſame at oppoſit points: which interſections or croſſynges, are ſhewed by the Needle or wiers of the Cumpas touched with the Magnes or the Lodeſtone.

The Azimuth of the Sun is a great circle, paſſyng by the Zenith and the true place of the Sun: croſſyng the Horizon at right Angles in oppoſit poincts, and diuidyng the ſame into two equall parts. And it is ſaid to be giuen when the diſtance thereof from the true meridian is knowne.

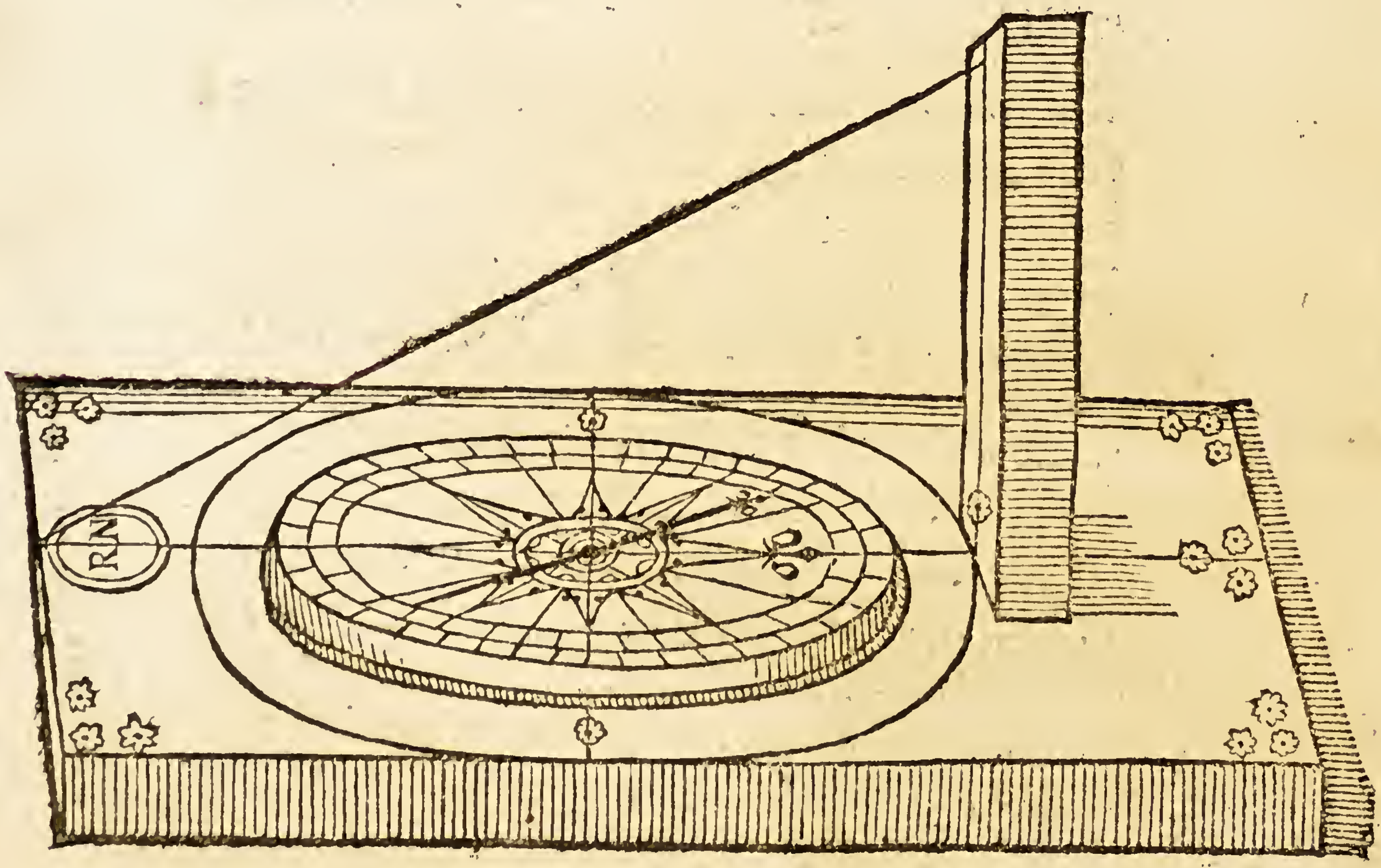
The Azimuths of the Sun vpon equall eleuations in forenoone and afternoone, haue equall diſtances from the true meridian, ſo that the middle poinct of the whole difference of any two Azimuths obſerued vppon equall eleuations in forenoone and afternoone, is the true meridian.

This difference of Azimuths is found vppon the Inſtrument of Variation, by addyng together the Variations of the Sunnes ſhadowe at equall eleuations in fornoone and afternoone. The half whereof is the diſtance of the Azimuths from the true Meridiān: the whiche compared with either of the ſame variations of the Sunnes ſhadowe, the difference ſhalbe the variation of the Needle from the true meridian.

Or els ſubtracting the leſſer variation of the Sunnes ſhadowe, from the greater (at equall eleuations) the halfe of the remayner ſhall be the true variation of the Needle from the meridian.

But the Azimuth of the Sunne beyng otherwiſe giuen, and the variation of the ſhadowe likewiſe giuen, the difference betweens them is the variation of the Needle.

The Variation of the Sunnes ſhadowe I call, the Horizontall diſtance betweene the Azimuth of the Sunne and the magneticall circle, whiche are repreſented in the Inſtrument by the ſhadowe of the line and the Needle.



¶ The

❡ *The maner how to vſe the Inſtrument of Variation.*

❡ *The ſecond Chapter.*

FIrſt you muſt place the Inſtrument vpon ſome Stoole, or other thyng that is flat, ſo as it may ſtande leuell, and the Plummet in the Standerd which is placed at the North ende of the fixed Flye, may fall perpendicularly with the line in the ſame Standerd.

You muſt haue regard that in remouing the Inſtrument to the Sunne as he goeth about, it may alwaies ſtande leuell as aforeſaied.

You are then to conſider, that the ſtring that recheth from the South part of the Inſtrumēt, to the top of the Standerd, is the chiefeſt ſtring to giue the Sunnes ſhadow, which muſt be ſo directed by turnyng the Inſtruments South ſide to the Sunne wards, that the ſhadowe of the ſame may fall directly longſt vpon the line of South and North in the fixed Flye, for it ought not to croſſe or decline from the ſame line in any part, but if it do, you muſt ſeeke to reforme it by ſetting the Standerd more vpright, or remouyng it at the South end.

Then muſt you alſo ſee, that the ſtring that is faſtned to the hoope of Braſſe that enuironeth the fixed Flye, maie be ſo placed, that it agree iuſtly with the ſhadow of the former line, and the line of South and North in the fixed Flye, in ſuch ſort that both the ſhadowes maie be as it were hidden in the ſaied line of the Flye: which you maie doe aptly, by turnyng the ſaid hoope, and remouyng the ſame line at either ſide of it, as you ſhall ſee cauſe.

The Inſtrument beyng duly placed in forme aforeſaid, it differeth nothyng from the Cumpas of Variation, but onely in this poinct, that whereas the Flye of the Cumpas of Variation, is ſo turned by vertue of the Magneticall wiers, that the North poinct thereof doeth ſhew the Pole of the Magnes or line of Variation: In this Inſtrument, the North poinct of the Needle doeth ſupply that, whiche the North poinct of the Cumpas ſhould doe. And the North poinct of the Flye which is fixed in the bottome of the Inſtrument, doth alwaies aunſwere to the ſhadowe that the Sunne giueth.

¶ How to finde the variation of the Needle or Cumpas at any place, the eleuation of the Pole, and ſituation of the meridian vnknowne.

¶ The third Chapter.

When you would obſerue the variation in any place, you muſt begin in yͤ fornoone, the ſooner, the better, and the more effectuall maie your obſeruatiōs be, do thus.

Take your Aſtrolabe and obſerue duly the height of the Sūne, for your more eaſe it ſhall bee beſt for you to note the ſame, when it agreeth to be iuſt vppon a degree, without any conſideration of minuts or fractions, and at the inſtant of the ſame height, turne your Inſtrument to the Sunne, ſo as the ſhadowe of the lines maie fall iuſtly vppon the line of South and North in the fixed Flye.

Then, when the Needle doeth ſtande, looke directly ouer the North poinct of the Needle, what degree and fraction, if there be any, doth aunſwere vnto the ſame in the fixed Flye, that is to ſaie, how many degrees it is from the North of the fixed Flye, which you ſhall note diligently, and may ſaie, that ſo many degrees &c. is the variation of the Sunnes ſhadowe from the North, as the North poinct of the Flye is from the North poinct of the Needle, either Eaſtwardes or Weſtwardes as you ſhall finde the ſame. Thus maie you obſerue diuers tymes, vpon ſeuerall degrees of the Sunnes eleuation. And like as you doe in the fornoone, ſo muſt you alſo obſerue the Sunnes eleuation in the afternoone, vpon the ſame degree of height, and with the ſame ſide of the Aſtrolabe and Index turned towardes the Sunne, as it was in the fornoone, (for auoydyng of error that maie bee in the Inſtrument) notyng at euery height what you finde the variation. And when the Sunne commeth to the meridian, it ſhall be good that you exactly obſerue his eleuation vpon the ſame, for knowyng the true Latitude of the place: all whiche you ſhall ſet downe in forme followyng.

Example.

In Limehouſe the ſixteenth of
October. Anno. 1580.

Fornoone.			Afternoone.				
Eleuation of the Sunne.	*Variation of the ſhadow from the North of the Needle to the Weſtwardes.*		*Eleuation of the Sunne.*	*Variation of the ſhadow from the North of the Needle to the Eaſtwards.*		*Variation of the Needle from the Pole or Axis.*	
Deg.	Degr.	Min.	Deg.	D.	M.	D.	M.
17	52	35	17	30	0	11	17 $\frac{1}{2}$
18	50	8	18	27	45	11	11 $\frac{1}{2}$
19	47	30	19	24	30	11	30
20	45	0	20	22	15	11	22 $\frac{1}{2}$
21	42	15	21	19	30	11	22 $\frac{1}{2}$
22	38	0	22	15	30	11	15
23	34	40	23	12	0	11	20
24	29	35	24	7	0	11	17
25	22	20	25	Fró N. to w. 0.8′		11	14

The eleuation of the Sunne vppon the meridian 25.d.58′. *the declination* 12.d.30′. *whiche I adde to the eleuation, becauſe the Sunne hath South declination, and thereof amounteth* 38.d.28′. *the eleuation of the Equinoctiall, the whiche I ſubtract from* 90.d. *the reſt is* 51.d.32′. *the eleuation of the Pole Artik.*

Now are you to conſider, that out of the greater variation of ſhadow vpon any degree of the Sunnes eleuation, is to be taken the leſſer of the ſame degrees eleuation, whether it bee in the fornoone or afternoone, (except the ſame variations be bothe one waie from the North of the Needle, whiche then are to be added) the halfe of the remayner is the variation of the Needle or Cumpas from the Pole or true meridian.

In the former obſeruations, I do finde the greateſt variation in the fornoone, for, at 17.d. eleuation, the variation is 52.d.35′. from North to Weſt: And at the ſame eleuation in the afternoone, I finde the variation to be but 30.d.0′. frõ North to Eaſt. I take the leſſer out of the greater and finde remayning 22.d.35′. the half thereof is 11.d.17′.½. So much I ſay is the Pole Artik, and true meridian line that paſſeth to the Pole by our Zenith at London, to the Weſtwardes of the North that the Needle ſheweth. And therefore the Needle or Cumpas varieth from the true Northe 11.d.17′.½. to the Eaſtwardes.

Alſo at 25.d. eleuation in the fornoone the variation is 22.d.20′. from North to Weſt: at the ſame eleuation in the afternoone the variation is 0.d.8′. from North to Weſt. Now becauſe the variations are both one way, (that is to the Weſtwardes) I adde them together (and ſo ought you to doe as often as you finde the variations ſo to agree) and I finde that they amount to 22.d.28′. the half thereof is 11.d.14′. which is the variation.

The variations of the Needle or Cumpas by the former obſeruations, are ſet out towardes the right hand againſt euery degrees eleuation, and conferryng them all together, I do finde the true variation of the Needle or Cumpas at Lymehouſe to be about 11.d.$\frac{1}{4}$.or 11.d.$\frac{1}{3}$. whiche is a poinct of the Cumpas iuſt or little more. So that in a Cumpas whoſe wiers are ſet directly vnder the flowre de Luce, the North and by Weſt, and South and by Eaſt poincts doe ſhewe the true meridian.

¶ The eleuation of the Pole and place of the Sunne giuen how vppon the Globe, to finde the variation of the Needle by any one obſeruation, either in fornoone or afternoone.

¶ The fourth Chapter.

In the former declaration, the onely way to try the variation, is by comparyng of the ſeuerall correſpondent obſeruations of the Sunnes eleuation in the fornoone, with thoſe of the afternoone, ſo that if the Sunne ſhould bee obſcured, or by any other occaſion like obſeruation can not be made in the afternoone, then the former rule giueth not the deſired purpoſe. Therefore I thought good to ſhewe, how by any one obſeruation in the fore or afternoone, the eleuation of the Pole and place of the Sunne giuen, you maie knowe the true meridian and the variation of the Needle from the ſame in any place, whiche thing maie be done and aptly demonſtrated vpon the Globe, but moſte exactly calculated by the Table of Sines.

To finde out the variation vpon the Globe, you muſt firſt ſet your Globe to ſtande dewly accordyng to the eleuation of the Pole at the place propoſed. Then ſeeke in the Ephemerides for the true place of the Sunne that daie, and note it with ſome ſmall prick in the ecliptik of the Globe. And placyng the Quadrant of Altitude or moueable verticall, at the verticall poinct or Zenith, take the eleuation of the Sunne obſerued by the Aſtrolabe or other Inſtrument at the tyme propoſed, and note it iuſtly vppon the ſame quadrant of altitude. Then turne your Globe and quadrant towardes that part of the Horizon that the Sunne was in at the tyme of the obſeruation, till the pricke you made for the place of the Sunne in the ecliptik, concur and agree iuſtly with the eleuation marked in the ſaid quadrant of altitude. So ſhall you ſee the quadrant ſhewe you vpon the Horizon, the Azimuth and diſtance of the Sunne from the true meridian of that place, whiche you ſhall compare with the variation obſerued vppon the Inſtrument at that inſtant of the Sunnes eleuation, And if they agree and concur iuſt, then ſhall you bee in the true and common meridian, whiche ſheweth the Pole of the worlde and Pole of the Magnes or Lodeſtone: But if thei differ, you ſhal ſubtract the leſſer from the greater, the remayner ſheweth the variation. And if the variation vpon the Inſtrument be greater then the true diſtance of the Azimuth from the meridian founde vppon the Globe, the ſame ſurplus is to be accompted for variation, vpon the contrary ſide of the meridian: if it bee leſſe, it is to bee accompted on the ſame ſide of the meridian that the variation is taken, whether it bee in the fornoone or afternoone. This precept needeth no further demonſtration, then the Inſtrument it ſelf, the Globe I meane.

But for example of the worke, I take the firſt obſeruation, in the former Chapter ſpecified, made at Lymehouſe the ſixteenth of October 1580. in the fornoone, which is 17.d. eleuation, and variation 52.d.35'. from North to Weſt.

Firſt I ſet my Globe at 51.d.32'. for the eleuation of the Pole. Secondly I take the place of the Sunne 2.d.55'.m. and note it vpon the Ecliptick. Thirdly I note vpō the quadrant of altitude, the eleuation of the Sunne 17.d. This done, I moue the quadrant of altitude towardes the Eaſt of the Horizon, and turne the Globe till the prick in the Eclipticke for the place of the Sunne, doe agree iuſtly, with the eleuation noted vppon the quadrant of altitude, and finde the true Azimuth ſhewed by the ſaid quadrant vpon the Horizon to be nereſt, about 41.⅓. from the meridian. And conferryng the ſame with the variation founde vppon the Inſtrument 52.d.35′. I find the difference 11.d.15′. And becauſe the obſeruation is noted to be in the fornoone frō the North to the Weſt, or South to the Eaſt, and the variation vppon the Inſtrument greater then the Azimuth founde on the Globe, I accompt the ſame from the North to the Eaſt, or from the South to the Weſt. So I conclude the variation at Lymehouſe to be about 11.$\frac{1}{4}$. from North to Eaſt, or South to Weſt.

¶How to finde the variation by Arithmeticall calculation vpon any one obſeruation in the fornoone or afternoone, the Latitude of the place, and declination of the Sunne beyng giuen.

¶*The fift Chapter.*

THE ſumme of the worke, is to finde the ark of the Horizon, betweene the meridian and the Azimuth of the Sunne at the time of the obſeruation, whiche beyng compared with the variation founde in the Inſtrument, the difference is the variation of the Needle. For attaynyng of the ſame arke. Firſt it is neceſſarie to haue the arke of the Equinoctiall betweene the Sunne at the tyme of the obſeruation, and the meridian, which ark is thus found.

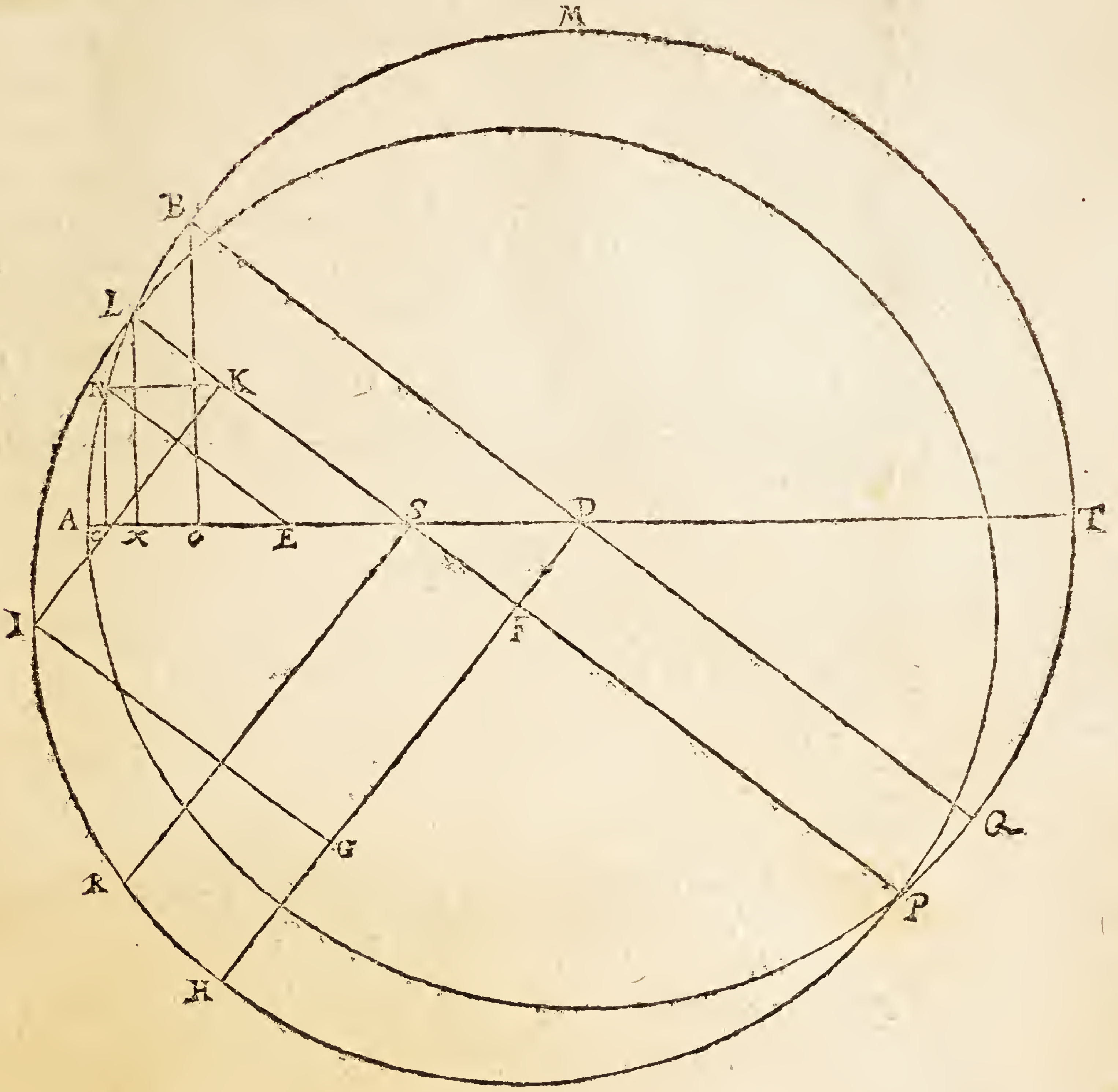
Multiply the ſine of the Sunnes meridian altitude for the daie propoſed, by the whole ſine, the product diuide by the ſine of the eleuation of the Equinoctiall (or the complement of the Latitude) the quotient is the verſed ſine or ſhaft of the ſemidiurnall arke, whiche you ſhall note for the firſt nomber.

Then againe multiplie the ſine of the Sunnes eleuation at the tyme of the obſeruation, by the whole ſine, and the product diuide by the ſine of the eleuation of the Equinoctiall, the quotient ſubtract from the nomber you firſt noted, the reſt is the verſed ſine of the arke of the diſtance betwéene the Sunne and the meridian in the parallell that it is in for the tyme propoſed, in ſuche partes as the Semidiameter of the Equinoctiall is the whole ſine: but it is neceſſarie before you applie it any furder, to reduce it into ſuche parts as the Semidiameter of the parellell is the whole ſine, whiche you maie doe thus: Multiplie this remayner by the whole ſine, the product diuide by the ſine of the complement of the declination (which is the Semidiamiter of the parallell) the quotient is the verſed ſins in his proportionall parts.

This verſed ſine thus reduced and ſubtracted from the whole ſine, leaueth the ſecond right ſine, which you ſhall ſeeke in the Table of ſines, and thereby findyng his arke, you ſhall ſubtract the ſame from the quadrant or 90.d. the remayner is the arke of the forſaid parellell of the Sunne, which is anſwerable or correſpondent in degrees and minuts, to the arke of the Equinoctiall that you ſeeke. The reaſon of the precept is this.

As the right ſine of the eleuation of the Equinoctiall, is in proportion to the right ſine of the meridian altitude of the Sũne or any Starre: ſo is the whole ſine, to the verſed ſine of the Semidiurnall arke. And againe, as the right ſine of the meridian altitude, is to the right ſine of the eleuation of the Sunne or Starre at the tyme of the obſeruation: So is the verſed ſine of the Semidiurnall arke of the ſame, to the exceſſe or difference betweene the ſame verſed ſine and the verſed ſine of the diſtance from the meridian.

For the better underſtandyng of the premiſſes, I haue ſet downe this figure following, and wiſhe the Reader to conſider of the ſame with the 4. Pro. of the 6. of Euclide.



LEt AMT. be the meridian circle. BDQ. the common ſection of the meridian and Equinoctiall their playnes, whiche is alſo the diameter of both circles. ADT. the plaine of the Horizon. LHP. the parallell of the Sunne, whiche is deſcribed vpon the centre F. at the diſtance FL. whiche is the ſine of the complement of the declination. AB. the arke of the eleuation of the Equinoctiall. BO. the firſt right ſine thereof. AL. the arke of the meridian altitude. LX. the ſine thereof. AN. the arke of the Sunnes eleuation at the tyme of the obſeruation. N C. the ſine thereof. B D.the whole ſine in reſpect of the former arkes and ſines. L R.the Semidiurnall ark of the parallell. R S. the firſt right ſine thereof. S L.the verſed ſine of the ſame. L I.the ark of the Sunnes diſtance from the meridian. I K. the firſt right ſine thereof. I G.the ſecond right ſine, which is equall to K F. K L.the verſed ſine. N E.which is equall to K S.the differẽce of the 2.verſed ſines L S.and L K. L F. the whole ſine in reſpect of the arks and ſines of the parallel.

Now as B O. is to L X. ſo is B D. to L S. And as L X.to N C.ſo is L S.to N E. Or els thus, as B O.to N C.ſo is B D. to N E.

Example.

The 16.October.1580.in Lymehouſe.

The eleuation of the Pole Artik 51.d.32′. The declination of ehe Sunne 12.d 30′. The eleuation of the Sunne obſerued in the fornoone 17.d.0′. The variation of the ſhadow vpon the Inſtrument 52.d.35′.from North to Weſt.

38.28′. 90.0′. 25.58′.
BO. BD. LX. LS.
If.62205.giue.100000.—then.43784.giueth.70386.
38.28′. 90.0′. 17.0′.
BO. BD. NC. NE.
Againe if.62205.giue.100000.29237.ſhall giue.47001.

Now out of.L S.—70386.
take.N E.—47001.

Reſt.L K.—23385.

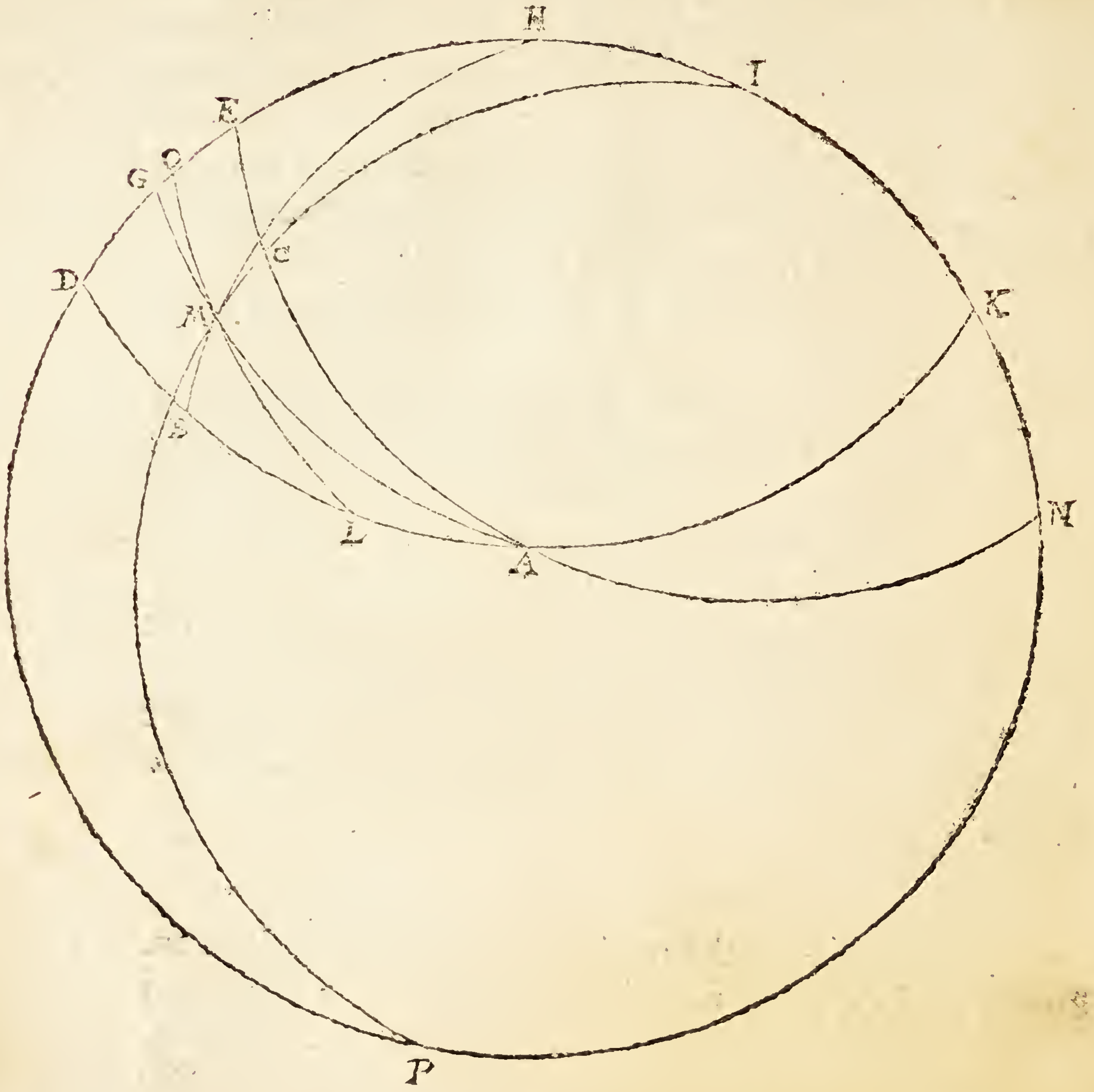
Then if L F.97629.the ſine of 77.d.30′.the complement of the declination, giue L F.100000.then L K.23385.giueth L K.23952.the verſed ſine of the arke I L. in his dew partes.

The ſame ſubtracted from L F.100000.the whole ſine,leueth K F.or I G.76048.the ſecond right ſine of the ſame ark ,which is the firſt right ſine of the arke I H.whiche arke you ſhall finde in the table of ſines to be 49.d.30′.24″.the complement whereof to the quadrant is 40.d.29′.36″.the arke I L.of the parallell betweene the Sunne and the meridian,whoſe correſpondent ark in the Equinoctiall,is the arke that was ſought.

Now hauyng this arke of the Equinoctiall, you muſt worke as followeth.

Multiply the ſine thereof, by the ſine of the complement of the declination,and diuide the product by the whole ſine,the quotient is the ſine of an arke contayned betweene the Sunne and the meridian, makyng right angles with the meridian. This ſine multiply by the whole ſine, the product diuide by the the ſine of the complement of the Sunnes eleuation at the tyme of the obſeruation,the quotient ſhalbe the ſine of the ark of the Horizon contained between the Azimuth of the Sunne and the meridian, whiche is the arke that was propoſed to be found.

LEt D H N P.be the meridian. D A K.the Horizon. E A N.the Equinoctiall. M.the place of the Sunne in the heauen at the tyme of the obſeruation. L M O. the parallell. H M B.the Azimuth or verticall circle paſſing by rhe Sunne. A M G.a greate circle imagined to paſſe by the Sunne,& to croſſe the meridian at right angles. I M P. a greate circle paſſyng by the Poles of the worlde,and place of the Sunne at the tyme of the obſeruation, commonly called the circle of houres, or circle of declination. C M.the South declination of the Sunne. M P.the complement thereof to the quadrant. M G.the ark between the Sunne and the meridian of rhe former imagined circle.A M G M O.the ark of the Sunnes parallell,E C.the correſpondent ark of the Equinoctiall,which are giuen in the former work. M B.the eleuation of the Sunne at the tyme of the obſerua-



tion. M H.the complement thereof. B D.the ark of the Horizon intercepted betweene the Azimuth and the meridian, which is the thing required to be found.

In this figure the Reader is to conſider the maner of the ſphericall triangles, and to compare the ſines of their ſides, according to the doctrine of Copernicus.in the 14.Chapter of his firſt booke, and of Regiomontanus.his 25.and 27.propoſitions of his 4.booke of triangles.

As P C.is to C E.ſo is P M.to M G.but 3. of them are giuen, therefore the fourth ſhall be knowen.

And as H M. is to M G. ſo is HB. to B D, the arke that is ſought, whiche by the three firſt giuen is likewiſe giuen.

The ſecond part of the example.

	90.0′.	*40.29′.36″.*	*77.30′.*	
	PC.	*EC.*	*PM.*	*MG.*
If.	*100000.giue.*	*64935.* —— *then.*	*97629.giueth.*	*63395.*
	73.0′.		*90.0′.*	*41.31′.22″.*
	HM.	*MG.*	*HB.*	*BD.*
Againe if.	*95630.giue.*	*63395.* ——	*100000.giueth.*	*66291.*

Whoſe ark BD.41.d.31′.22″.is the Horizontall diſtance of the Azimuth of the Sunne from the meridian, the thyng that was ſought.

Now comparyng the ſame with the variation found vpon the Inſtrument at the inſtant of 17.d.eleuation, which is 52.d.35′. I finde it to be leſſe, and therfore ſubtract it, and ſo haue I the difference 11.d.3′.38″. And becauſe the obſeruatiō was in the fornoone, and the variation vpon the Inſtrument greater then the arke of the Horizon betweene the Sunnes Azimuth and the meridian, therefore I conclude, that the variation is 11.d.3′.38″. from South to Weſt, or North to Eaſt, whiche is the thyng promiſed to be ſhewed.

But comparyng the ſame arke of the Horizon 41.d.31′.22″. with the variation founde at the correſpondent eleuation in the afternoone, which is 30.d.0′. I ſubtract the leſſer from the greater, and finde the exceſſe 11.d.31′.22″. whiche ſhould be the variation. And becauſe the variation founde vppon the Inſtrument is leſſe then the arke of the Azimuth vppon the Horizon, I accompt the variation on the ſame ſide of the meridian, whiche is from South to Weſt, or North to Eaſt.

This varietie betweene the obſeruation made in the fornoone, and that in the afternoone, proceedeth either of the imperfection of the Inſtrument, or negligence of the obſeruer. For in the rule there can bee no error, beyng grounded vppon Geometricall demonſtration, then whiche nothyng can bee more certaine.

The former preceptes and examples doe ſerue when the Sunne doth decline frõ the Equinoctiall either Northwards or Southwardes. But if the Sunne be in the Equinoctiall, then the maner of the workyng is more eaſie and brief. For if you multiplie the ſine of the Sunnes eleuation at the tyme of obſeruation, by the whole ſine, and diuide the product by the ſine of the eleuation of the Equinoctiall, whiche is the meridian altitude, the quotient giueth the ſeconde right ſine of the diſtance of the Sunne frõ the meridian, whiche is the firſt right ſine of the complement of the ſame arke: And entryng the table of ſines with it, you ſhall finde his arke, whiche if you ſubtract frõ the quadrant or 90.d. leaueth the arke of the diſtance of the Sunne from the meridian. And hauyng the ſame work thus. If the ſine of the complement of the eluation of the Sun at the tyme of the obſeruation, giue the ſine of the forſaid arke of diſtance, what ſhall the whole ſine giue. Multiplie and diuide, the quotient ſhalbe the ſine of the ark of the Horizon contayned betweene the Azimuth of the Sunne and the meridian. Which arke being compared with the variation of the Inſtrument in maner as before is ſhewed, giueth the variation required.

But the Sunne beyng in the Equinoctiall, if the place where the obſeruation is made, bee likewiſe vnder the ſame circle, then is the variation moſt eaſely obſerued, for that the Equinoctiall is the Azimuth of Eaſt and Weſt, therfore turnyng your Inſtrument onely to receiue the ſhadowe of the Sunne, and looking then to the North poinct of the Needle, if you finde the ſame to aunſwere to the quadrant or 90.d. you ſhall be in the meridian of the Magnes, whiche paſſeth by the Poles of the world, but if it doe differ from 90.d. the ſame difference is the variation of the Needle.

But admittyng the obſeruer to be vnder the Equinoctiall, and the Sunne to haue declination, then the proportion of the ſine of the complement of the eleuation at the tyme of the obſeruation, vnto the ſine of the declination, ſhalbe ſuche, as the whole ſine, is to the ſine of the arke of the Horizon included betweene the Azimuth of East and West, which is the Equinoctiall it ſelf, and the Azimuth of the Sunne for the tyme of the obſeruation, the complement whereof giueth the true meridian, whiche complement you maie compare with the variation ſhewed vpon the Inſtrument, the difference is the variation.

Diuers other caſes might bee propoſed, and rules giuen for them, whiche for breuitie I omit.

But one thyng I thought good to admoniſhe you by the waie, that whereas I haue ſhewed in the firſt part of this propoſition the maner to finde the two verſed ſines, the one of the Semidiurnall arke, the other of the arke of the diſtance of the Sunne from the meridian. By the firſt, the Semidiurnall arke being found and reduced into houres and minuts of time, is ſhewed the iuſt half quantitie of the daie. And by the arke of the other likewiſe reduced, the houre of the day, or the tyme contained betweene the noonſteed and the inſtant of the obſeruation. As in the ſame example. The verſed ſine of the Semidiurnall ark LS. is giuen 70386. in ſuche parts as the Semidiameter of the Equinoctiall B D. is 100000. therefore I reduce the ſame into ſuch parts as the Semidiameter of the parallel L F. is 100000. and finde it to be 72095. which ſubtracted from the whole ſine L F. 100000. there reſteth S F. 27905. whiche is the ſecond right ſine of the Semidiurnall ark L R. and the right ſine of R H. 16. d. 12′. whiche is the complement of the Semidiurnall ark L R. wherefore ſubtractyng it from the quadrant L H. or 90. d. reſteth 73. d. 48′. the Semidiurnall ark L R. the ſame reduced into partes of tyme allowyng 15. d. for an houre 15′. for a minut, and 15″. for a ſeconde of tyme, and for euery degree 4. minuts of tyme, for euery minut 4″. and for euery ſecond 4‴. &c. I finde the time of that ark from the poinct aſcendent, to the meridian, whiche is halfe the day, to bee 4. houres 55′. 12″. and conſequently the whole day beyng the 16. of October aboue written, to be 9. houres 50′. 24″. long.

This example maie ſerue for a generall precedent, whiles the Equinoctiall is betweene the Sunne & the eleuated Pole, but if the Sunne be between the eleuated Pole and the Equinoctiall, then will the verſed ſine fall out to be greater then the whole ſine, and the Semidiurnall arke to exceede a quadrant. Wherefore hauyng reduced the ſame into his proportionall parts, as before is ſhewed, ſubtract from it the whole ſine, the ſurplus is the ſine of the exceſſe of the Semidiurnall arke aboue a quadrant, whiche beyng added to the quadrant, giueth the Semidiurnall arke.

By the other verſed ſine of the diſtance of the Sunne from the meridian, which is L K. 23952. in ſuch parts as the whole ſine or Semidiameter L F. is 100000. ſubtracted from the whole ſine, is giuen K F. 76048. the ſecond right ſine of the ſame ark of diſtance, and the firſt right ſine of 49. d. 30′. 24″. which is the complement of the ark of the Sunnes diſtance from the meridian: therefore ſubtractyng the ſame from 90. d. reſteth 40. d. 29′. 36″. the arke of the diſtance betweene the Sunne and the meridian, which beyng reduced into partes of time as before, giueth 2. houres 41′. 58″. and the ſame (becauſe it is in the fornoone) deducted from 12. houres the noonſteed, reſteth 9. houres 18′. 2″. the iuſt inſtant of the tyme of the day.

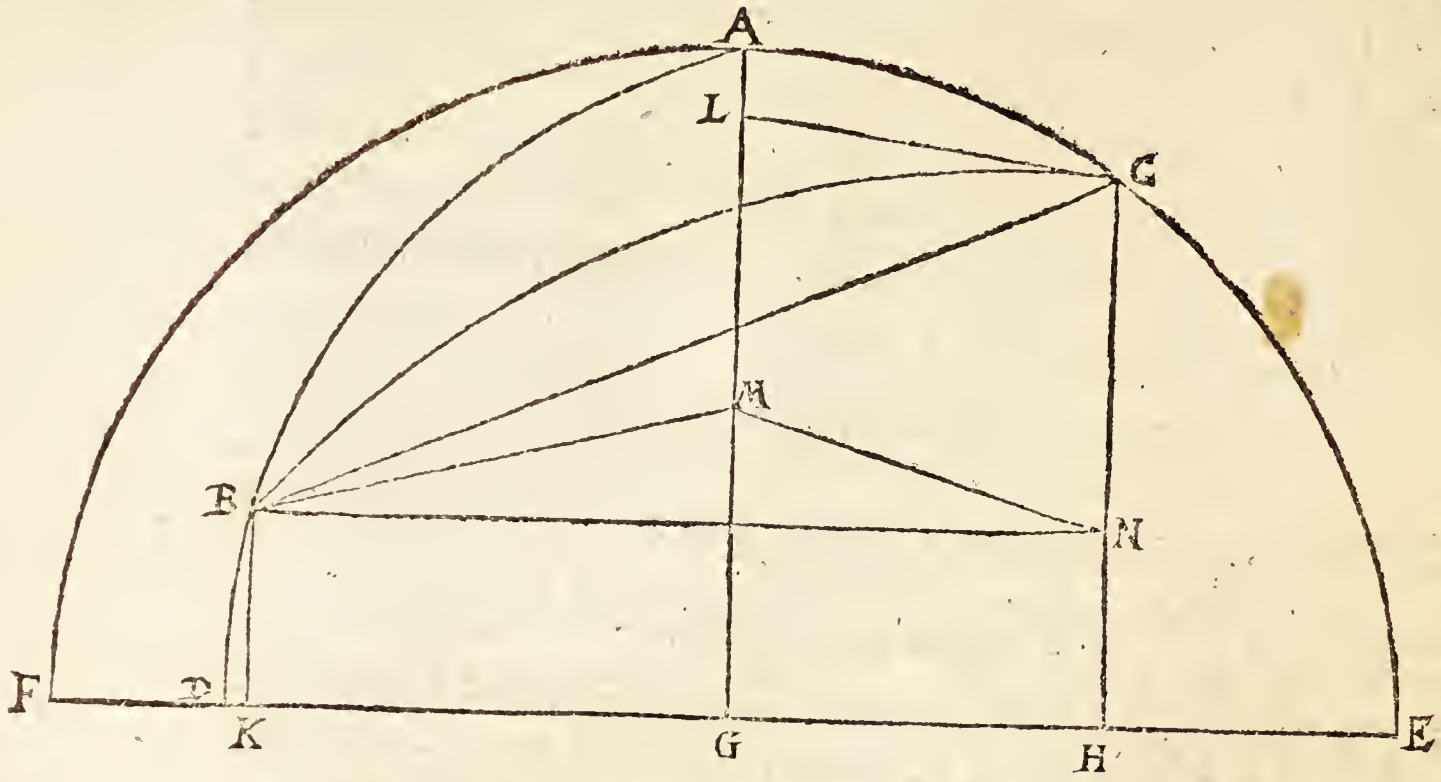
But if this verſed ſine be found to be greater thē the whole ſine (as it maie when the Sunne is betweene the Equinoctiall and the eleuated Pole, and before the houre of ſixe in the mornyng and after the houre of ſixe in the euenyng) then doth the arke of diſtance conſequently exceede a quadrant, the ſine of this exceſſe is the ſurplus of the verſed ſine aboue the whole ſine. Whoſe arke added to the quadrant giueth the arke of the Sunnes diſtance from the meridian, and reducyng the ſame into parts of tyme, is giuen the inſtant of tyme of the obſeruation.

As by this meanes (the eleuation of the Sunne being preciſely obſerued and Latitude knowen), the inſtant of time of yͤ daie is giuen more exactly, then by any Clock, Diall or other Inſtrument. So if there might be had a portable Clocke that would continue true the ſpace of 40. or 50. houres together (if longer tyme the better) then might the difference of longitude of any two places of knowen Latitudes, whiche conueniently may be trauelled within that time, be alſo moſt exactly giuen. And in this ſort trauelling and obſeruing from place to place, might the longitudes of any Countrey be perfectly deſcribed.

¶ An other way moſt generall, how to finde the Variation by one obſeruation either in the fornoone or afternoone, the eleuation of the Pole and declination of the Sunne beyng giuen.

¶ The ſixt Chapter.

FOR the accompliſhyng of this propoſition, you are to imagine a ſphericall triāgle vppon the ſuperficies of the Globe, whoſe ſides muſt be. Firſt the portion or arke of the meridian betweene your Zenith and the Pole, whiche is the complement of the latitude. The ſecond the ark of the verticall circle contayned betweene your Zenith and the Sunne, which is the complement of the Sunnes eleuation at the tyme of the obſeruation. The third ſide is an arke of the circle of declination comprehended betweene the Sunne and the eleuated Pole, this arke is found by addyng, or ſubtractyng, the declination of the Sunne, to or from, the quadrant or 90.d. whiche muſt be done with this conſideration, that if you be on the ſame ſide of the Equinoctiall that the Sunne is, you are to ſubtract the declination from the quadrant. If on the other ſide, to add it to the ſame, ſo haue you the three ſides of the ſphericall triangle giuen. Then the ſubſtance of the work conſiſteth in findyng the quātitie of the angle of the ſame triangle at the Zenith, for the complement thereof to the Semicircle or two right angles, is the Horizontall diſtance of the Sunnes Azimuth from the meridian, which beyng compared with the variation of the Sunnes ſhadowe vppon the Inſtrument, giueth the thyng required.



LEt F A C E.be the meridian, wherein A.the Zenith, C. the Pole. A D. the verticall circle or Azimuth of the Sunne paſſyng by B.the place of the Sunne at the tyme of the obſetuation. B D.the eleuatiō of the Sunne. B A. the complement of the eleuation. A C.the complement of the latitude. B C.the ark of the circle of declination, or the chord of the ſame ark. F G E.the plaine of the Horizō.

Now from the three angles of the triangle A B C. let fall 3.perpendicular lines to the plaine of the Horizō A G. C H. and B K. and by the 6. of the 11. of *Euclide*, theſe three lines ſhall be parallelles.

Then let fall a perpendicular line from C.vppon A G.in the poinct L.from B.an other perpendicular vppon the ſame line A G.at the poinct M.And from the ſame point M. erect a perpendicular line to N. which ſhalbe parallell and equall to L C.Then ioyne B.and N. together. So haue you a right-lined triangle.B M N.whoſe angle at M.is equall to the angle A.of the ſphericall triangle A B C. By the 4.definition of the 11.of *Euclide*,for the like reaſon is of obtuſe angles as of acute or ſharp.And the ſides therof B M.and M N are giuen B M.the ſine of B A.and M N.equall to L C.the ſine of C A.

And the third ſide B N.is found by ſubtracting the ſquare of N C.frõ the ſquare of the chord B C, as in the 47.of the firſt of *Euclide*.

And in rightlined triangles, the three ſides beyng giuen, the angles are alſo giuen, by the 44.45.&c.of the firſt of *Regiomontanus*, and by the 7.propoſition of the 13.Chapter of *Copernicus* his firſt booke.

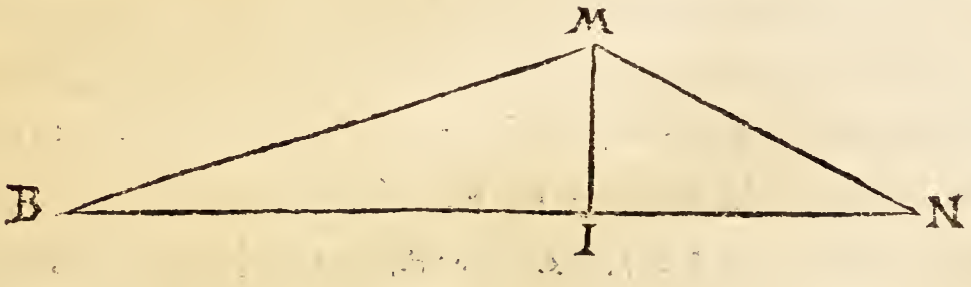
For example I take the former obſer-
uation of the 16.October 1580.
and work as followeth.

The eleuation of the Pole C E.51.d.32′.the ſine thereof C H.78297. The eleuation of the Sunne B D.17.d 0′.the ſine thereof B K.29237. The arke B C.102.d.30′.the chord thereof B C.155976. The complement of the eleuation of the Sunne B A.73.d.0′.the ſine thereof B M.95630. The complement of the latitude A C.38.d.28′.the ſine therof L C. 62205. equall to M N. Now out of C H.78297.ſubtract N H.equall to B K.29237.Reſt N C.49060.

Then out of the chord B C.ſquared.——24328512576.
Take the ſquare of N C.——————2406883600.

Reſt the ſquare of B N.——————21921628976.
The roote thereof is.148059.the ſide B N.

So are the three ſides of the triangle giuen. $\left\{\begin{array}{l}\text{B N. 148059.}\\ \text{M N. 62205.}\\ \text{B M. 95630.}\end{array}\right.$



Now to finde the angle M. I ſubtract from the ſquare of B M.the bigger ſide, whiche is. 9145096900. the ſquare of

M N. the leſſer ſide, which is. 386946 2025. Reſt 527563 4875. which diuided by the baſe B N. 148059. giueth. 35631. which number I take out of the ſaid baſe reſt. 112428. the half thereof. 56214. is I N. the leſſer caſe or ſhorter parte of the baſe diuided by the perpendicular line M I. fallyng vpon the ſame frō the obtuſe angle M. whiche ſubtracted from the whole baſe B N. 148059. leaueth I B. 91845. the greater caſe or longer part thereof.

Now it is manifeſt that theſe two caſes or parts of the baſe B I and I N. are the ſines of the two ſharpe angles I M B. and N M I. made of the obtuſe angle M. by the perpendicular fallyng from the ſame angle to the baſe, and the arks of them ioyned together, are the quantitie of the obtuſe angle N M B.

Therefore to reduce them to the nombers of the ſines, firſt for the greater caſe B I. making B M. the whole ſine, ſay.

B M. B M. B I. B I.
If. 95630. giue. 100000. — then ſhall. 91845. giue. 96042.

The ark thereof is 73. d. 49′. 38″. Againe for the leſſer caſe, making M N. the whole ſine, ſay.

M N. M N. I N. I N.
If. 62205. giue. 100000. —— then. 56214. giueth. 90376.

Whoſe ark is 64. d. 38′. 45″. And addyng theſe two arks together they giue 138 d. 28′. 23″. the ark or quantitie of the obtuſe angle N M B. equall to the ſphericall angle B A C. And deductyng it frō the Semicircle 180. d. there reſteth 41. d. 31′. 37″. the angle F A D. the Horizontall diſtance of the Sunnes Azimuth from the meridian, & ſubtractyng that from 52. d. 35′. the variation found vppon the Inſtrument from North to Weſt in the fornoone, reſteth 11. d. 3′. 23″. the variation of the Needle from the meridian, the thyng that was propoſed to be found. And comparyng the ſame with the afternoones obſeruation, you ſhall finde it 11. d. 31′. 37″. the cauſe of this difference i haue declared in the former Chapter.

If the Reader be delighted with varietie of demonſtration of this matter, let him peruſe the 34. propoſition of the 4. of Regiomontanus, and the 13. propoſition of the 14. Chapter of the firſt booke of Copernicus.

But whereas you ſee this calculation to differ from the former in ſome odde ſeconds, the reaſon thereof is not as it might bee taken the different nature of the rules, but in workyng thereof, omitting the fractions in the diuiſions, and neglectyng the proportionall parts of the ſines and arks.

In theſe exãples I haue uſed yͤ abridged table of 100000. the whole ſine, which though it giue ſome eaſe in the working, yet it is not ſo exact as that of 10000000. of Eraſmus Reinholdus. Unto the which, with his Canon fœcundus aunſwerable to the ſame, if the third Canon of the Hypothenuſaes were annexed, we ſhould haue an entire table for the doctrine of triangles, that might worthely bee called The table of tables. Whiche thyng though Georgius Ioachimus Rheticus, haue well begun and framed it orderly frõ ten minuts to ten: yet is it left very rawly for ſuche as deſire the exact truth of thynges. I haue therefore for myne owne eaſe and uſe, calculated the complement of this table, and almoſt ended it, for the whole quadrant from minut to minut: whiche if in the meane tyme before I haue finiſhed, I ſhall not finde it extant by any other, I will publiſhe it for the commoditie of all ſuche as ſhall haue occaſion to uſe the ſame for Nauigation and Coſmography.

¶To finde the eleuation of the Pole, Situation of the meridian, and Variatiõ of the Needle at any place by the Sunne, vpon twoo obſeruations either in forenoone or afternoone.

¶*The ſeuenth Chapter.*

Whereas in the three laſt Chapters, the groundes of the calculations conſiſt in the eleuation of the Pole to be giuen, which thyng to knowe is no leſſe difficult, then the cheef matter that is by them required. For the common precepts, whiche as yet haue cheefly been giuen for the findyng thereof, depende onely vppon the obſeruation of the meridian altitude of the Sunne or Starres, or els vppon certaine falſe and groſſe rules of the guardes and Pole ſtarre. Therefore I haue thought good, that as I haue ſhewed the waie to know the variatiō vpon any one obſeruation, either in forenoone or afternoone, the latitude of the place preſuppoſed: ſo likewiſe, vpon twoo obſeruations by the Sunne, either in forenoone or afternoone, to ſette doune the waie and maner how to finde the eleuation of the Pole, ſituation of the meridian, and variation of the Needle in any place by the Globe.

But this you muſt alwaies regard, that your two obſeruations maie haue conuenient diſtance of tyme betweene them, the greater the better: So as the higher eleuation bee not taken nere the meridian, the lower eleuation the nerer it is taken to the Azimuth of Eaſt or Weſt, or to the Horizon, the better, with which eleuations, you are to note the difference of the Sunnes Azimuths or variations founde by the ſhadowe vppon the Inſtrument exactly, for without that, the eleuations onely are in vaine.

Firſt it is requiſit, that your Globe be ſo fitted, that the meridian circle and the Horizon doe croſſe eche other at right angles, and diuide them ſelues equally into Semicircles. And alſo that the quadrant of altitude (or moueable verticall) bee placed duly vpon the meridian circle at the Zenith, ſo as being turned circularly, it may touche the Horizon equally in euery part. Theſe thinges beyng duly conſidered, there needeth not any further regard to bee had for placyng of the Globe, onely this you may reſpect in ſettyng the Pole at aduentures aboue the Horizon betweene it and the Zenith, that the meridian circle may cut the Horizon in iuſt degrees, ſo may your quadrāt of altitude be placed at your Zenith iuſtly vpon a degree alſo.

Then muſt you faſten your Globe to the Horizon, ſo as it may remaine immoueable, but in faſtnyng the ſame you muſt regard that you force it not from one ſide of the Horizon to an other, but that it reſt equidiſtāt in the ſame. And hauyng your Globe thus diſpoſed, it is ready for you to apply your obſeruations vpon, which you ſhall thus doe.

First, take your higheſt eleuation, and note it vpon your quadrant of altitude, and place the ende of the ſaied quadrant vpon the Horizon at 10.15.or 20. d. frō the meridian circle, (but the nerer you ſet the ſame to the meridian, the more conueniently, without impechement, will your triall bee made.) Then giue a pricke vpon the Globe in the Azimuth, that the quadrant ſheweth at the degree of the eleuation, noted vpon the quadrant, then againe note the leſſer eleuation vpon the quadrant of altitude, and remoue the ſame vpon the Horizon (from that place where it was firſt fixed, towardes the Azimuth of Eaſt or Weſt, whiche ſhalbe nereſt the ſame) ſo many degrees as you finde the difference of Azimuthes betwene the twoo eleuations by the ſhadowe of the Sunne, vpon the inſtrument of Variation, and ſtaiyng your quadrant of altitude vpon that poinct of the Horizon: note alſo your leſſer eleuation in the ſame Azimuth vpon your Globe. This doen you muſt haue a paire of Calliper compaſſes, ſuche as maie conueniently reche to 113. d. $\frac{1}{2}$. of the Equinoctiall of your Globe, (whiche is a quadrant, and the greateſt declination of the Sunne) then you muſt conſider whiche of the Poles of the worlde is eleuated aboue your Horizon, and whether your declination bee towardes, or from that Pole, that is to ſaie, whether the Sunne be betweene the eleuated Pole and the Equinoctiall, or the Equinoctiall betweene the Sunne and the Pole. If the Sunne bee betweene the Pole and the Equinoctiall, then are you to ſubtracte the declination from 90.d. If the Equinoctiall bee betweene the Sunne and the Pole, you muſt adde the declination to 90.d. And take the ſame remainyng or collected number of degrees &c. with your compaſſes vpon the Equinoctiall. And ſett the one ende of your compaſſe at the pricke made vpon your Globe, for the higheſt obſeruation, and with the other ende deſcribe an arke or peece of a circle, vpon the ſame ſide of the meridian that your pricke is on, from the meridian to the Horizon. Then againe with your compaſſe vnaltered, ſettyng the one foote in the pricke for the loweſt obſeruation, deſcribe an other peece of a like circle croſſyng the former. The poinct of the interſection, or croſſyng of theſe twoo circles, is the eleuated Pole, to the whiche if you remoue the quadrant of altitude, you ſhall finde what the eleuation thereof is. And the poincte that the ſame quadrant ſheweth vpon the Horizon, is the interſection of the meridian and the Horizon, the Horizontall diſtance betweene this interſection, and the Azimuth of the leſſer obſeruation, ſubtracted from the ſemicircle, or 180.d. leueth the Horizontall diſtaunce of the ſame Azimuth from the true meridian. So haue you the eleuation of the Pole, and ſituation of the meridian.

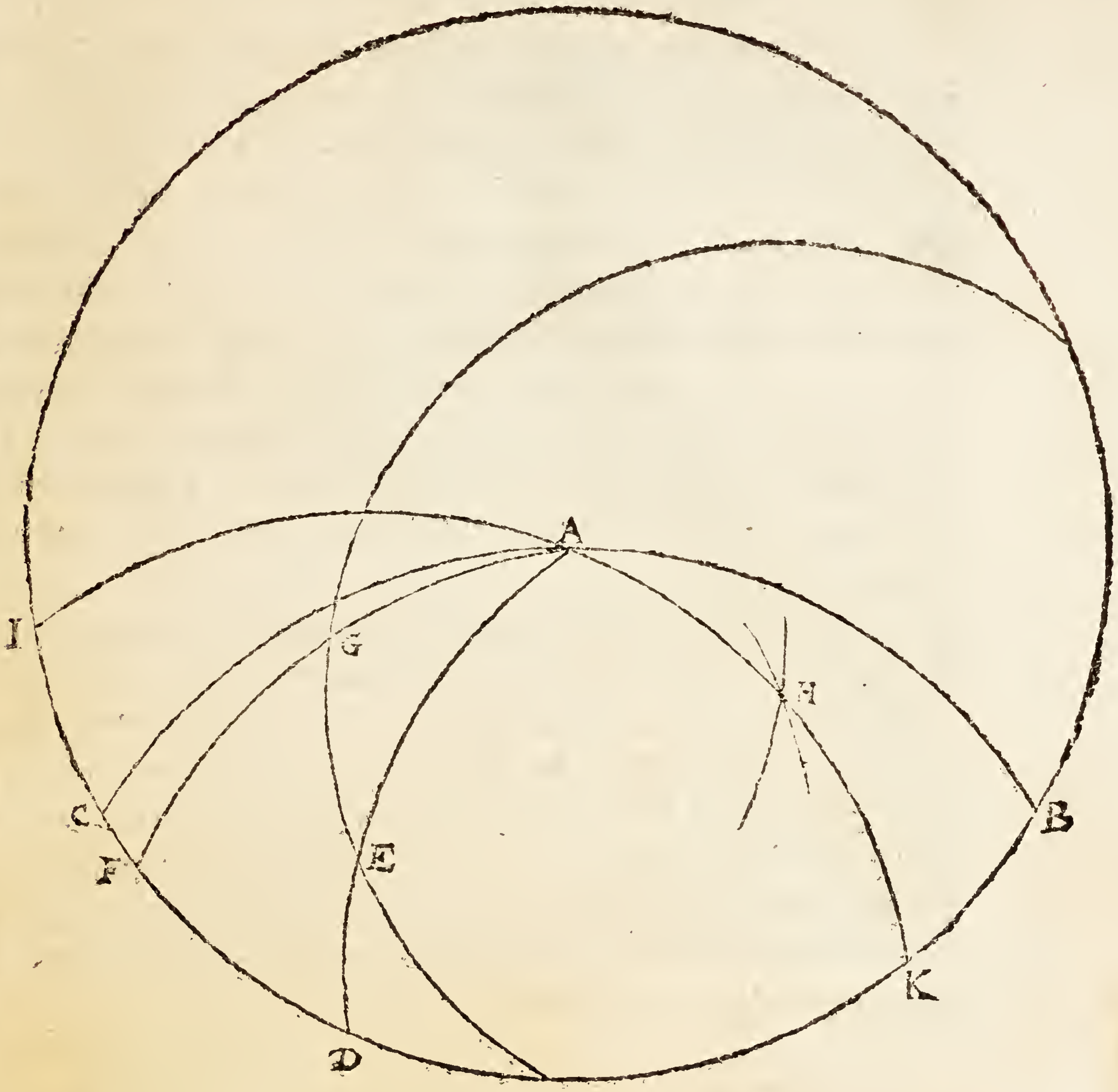
Now if you compare the Horizontall diſtance of the Azimuth of the Sunne, from the meridian at the tyme of the obſeruation, with the variation by the Sunnes ſhadow found vpon the inſtrument, at the tyme of the ſame obſeruation, and takyng the one out of the other, the remainer ſhalbe the true variation, whiche you are to accompte, as in the latter ende of the third Chapter is ſhewed. So haue you giuen the eleuation of the Pole, the meridian, and Variation of the Needle, the thynges propoſed to be ſhewed.

Example of twoo obſeruations made
at Limehouſe the 29. of Julie 1581. in the forenoone.

The firſt eleuation 21.d.0′. Variation 100.d. 30′. from North to Weſte. The ſeconde eleuation 50.d.0′. Variation 48.d.0′. from North to Weſte. Difference of the Azimuths 52.d.30′. The declination 16.d.14′. Northerly.

LEt I D B. be the Horizō of the Globe. C A B. the meridian circle. F G A. the Azimuth of the greater eleuation ſhewed by the quadrant of altitude vpon the Horizon at F. 10.d. from the meridian circle of the Globe C. F G.

the



the greater eleuation marked vpon the Globe at G. F D. the difference of the Azimuths vpon the Horizon. 52.d.30'. E. the prick of the leſſer eleuation marked vpon the Globe in the Azimuth A E D.

Then openyng your Cumpaſſes to 73.d.46'. of the Equinoctiall (which is the complement of the declination) and ſetting one ende vpon G. the poinct of the greater eleuation, deſcribe with the other ende, an ark or peece of a circle at H.

This done, ſet one foote of the Cumpas vnaltred in E. the leſſer eleuation, and with the other ende deſcribe a peece of a circle croſſyng the former ark at H. this interſection ſhall bee the eleuated Pole.

Then ſet the quadrant of altitude vnto the poinct H. and it will ſhewe the meridian to croſſe the Horizon at K. So ſhall you haue the eleuation of the Pole K H. 51.d.$\frac{1}{2}$. or there about, And the true meridian K A I. And from K. to D. the Horizontall diſtance 90.d.$\frac{3}{4}$. which ſubtracted from K I. 180.d. the ſemicircle of the Horizon, reſteth the ark D I. 89.d.$\frac{1}{4}$. the diſtãce of the Azimuth of the firſt obſeruation from the meridian I. which diſtance compared with the variation found vppon the Inſtrument at the firſt eleuation 100.d.30′. and deducted frõ the ſame, reſteth 11.d.$\frac{1}{4}$. Therefore I ſay, the true meridian ſhewyng the Pole Artik is 11.d.$\frac{1}{4}$. to the Weſtwards of the magneticall meridian ſhewed by the Needle, and conſequently the variation of the Needle 11.d.$\frac{1}{4}$. from the North to the Eaſt.

In this example the declination is ſubtracted from the quadrant, becauſe the Sunne is betweene the Equinoctiall and the eleuated Pole, but if the Equinoctiall were betweene the eleuated Pole, and the Sunne then ſhould you adde the declination to the quadrant, and with that diſtance taken vpon the Equinoctial with your Cumpaſſes, proceede as in the former example

Theſe examples that I haue ſhewed, and ſuche like experiments to be done vpon the Globe, are eaſie to be conceiued, and the reaſons very manifeſt: but the truth of the matter conſiſteth in the exactnes of the Inſtruments; and the orderly application and handlyng of them.

I might here haue annexed the maner, how vpon two obſeruations of the Sunnes eleuation in fornoone or afternoone and difference of the Azimuths, to calculate the premiſſes more exactly by the table of Sines and doctrine of ſphericall triangles: but that it is a very tedious way, and my meanyng is rather to giue the Reader a proof of the pleaſant vſe of theſe calculations (whiche I thinke I haue ſufficiently done in the former Chapters) then to cloy hym at the firſt with the hard and painfull practiſe of many examples. Notwithſtanding, for the ſatiſfaction of ſome, I will breefly ſet downe the grounde and ſumme of the work, which is this.

The complements of your two eleuations, are two ſides of a ſphericall triangle not rectangle. The angle by theſe two knowen ſides contayned at the Zenith, is giuen by the difference of the Azimuths or variations vppon the Inſtrument. Wherefore by the 28. of the 4. of Regiomontanus the third ſide (whiche is the ark comprehended betweene the two eleuations) and the other angles may be giuen.

Then haue you an other like triangle, whoſe three ſides are theſe: the firſt, one of the foreſaied complements of eleuation: the ſeconde, the arke of the circle of declination, betweene the Sunne at the inſtant of the ſame eleuation, and the eleuated Pole. The third ſide is an arke of the meridian betweene the Zenith and the Pole: whiche is the complement of the eleuation of the Pole, or latitude of the place. The twoo firſt ſides are alwaies giuen. For findyng the third ſide, it is neceſſarie to knowe the angle that the twoo giuen ſides containe, whiche is the difference of twoo angles, whereof one is an angle of the firſt triangle giuen, the other an angle contained betweene the arke of the circle of declination, and the third ſide of the firſt triangle, whiche angle is diuerſly founde, and beeyng founde and ſubtracted from the other angle, or that from it, the difference is the angle of this other triangle: And ſo haue you in the Sphericall triangle twoo ſides, and the angle by the ſame twoo ſides contained, giuen. And by the ſame 28. of the fowerth of Regiomontanus the thirde ſide is found, the complement whereof is the eleuation of the Pole.

And the eleuation of the Pole, and declination of the Sun beeyng giuen, the fowerth Chapter ſheweth by one obſeruation, to finde the Variation of the Needle.

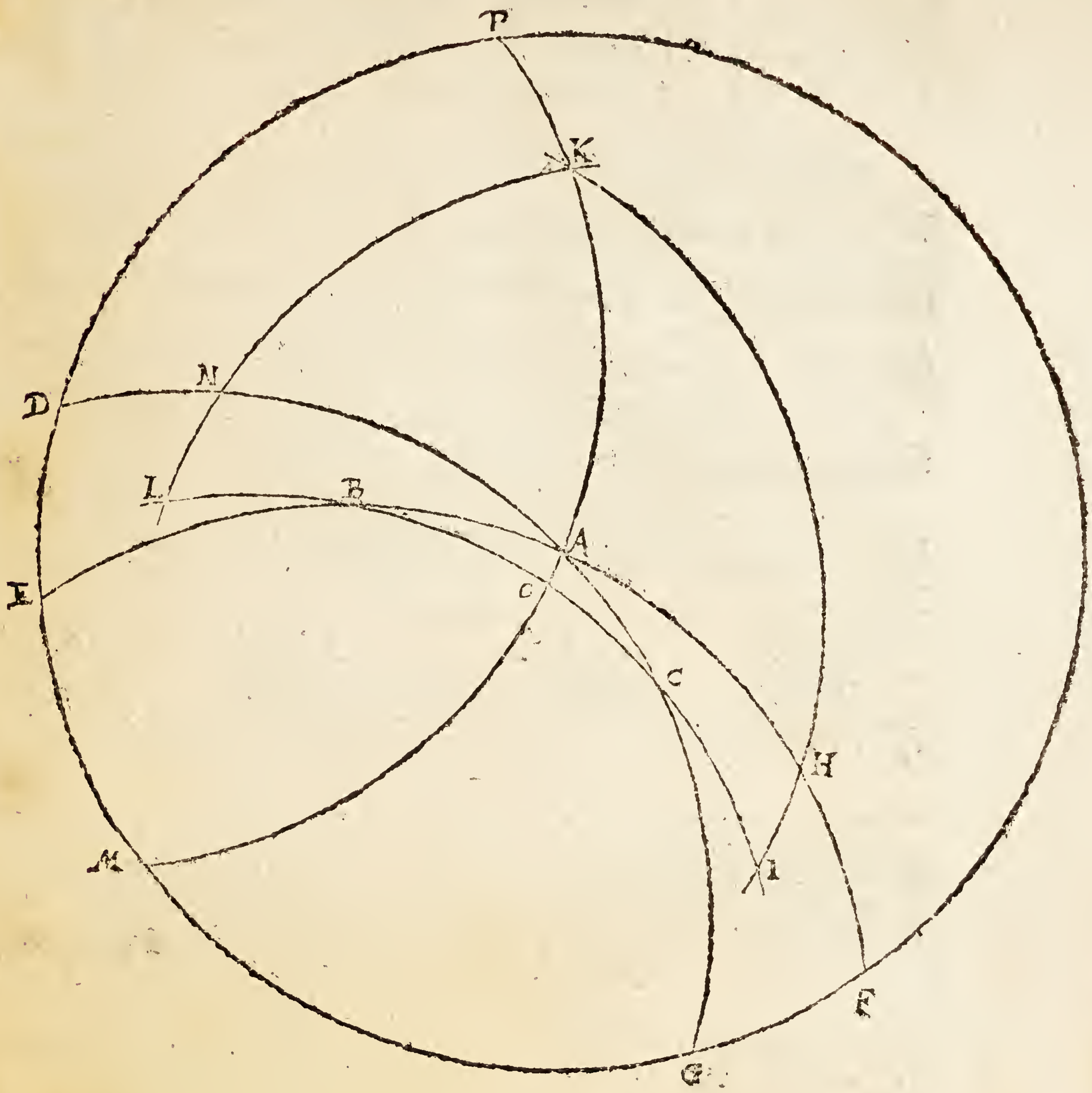
Of the Pole of the Magnes.

The eight Chapter.

Firſt it is to bee vnderſtoode, that by experience of trauellers, it is founde and confirmed, that the meridian common to the Pole of the worlde, and the Pole of the Magnes, (that is to ſaie, where the Compaſſe, or Needle touched with the Magnes, ſheweth the Pole of the worlde directly,) paſſeth at the Ilandes of the Açores, or nere there aboute, but I finde by greate probabilitie, that it is ſomewhat to the Eaſtwardes of thoſe Ilandes, and not to the Weſtwardes. From whiche meridian I accompt the beginnyng of longitudes, and finde our meridian of London, to bee from the ſame 23.d.$\frac{1}{2}$. our latitude as before ſaied 51.d.32′. and the Variation of the Compaſſe or Needle 11.d.$\frac{1}{4}$. from the North to the Eaſtwardes. Now vpon theſe groundes I find by calculation, the Pole of the Magnes, or the interſection of the twoo Magneticall meridians, vpon the ſuperficies of the earth, to bee from the Pole artike 25.d.44′. and in longitude 180.d. that is to ſaie, 25.d.44′. in the former common meridian, on the other ſide of the Pole.

It maie bee happely that ſome of you will bee deſirous to knowe the maner how this Magneticall Pole is founde out, that you maie apply the ſame to like purpoſe hereafter. Therfore I thought good to ſette doune an example of the former calculation.

Let A. bee the Pole Artik. P E F. the Equinoctiall. D A G. the common meridian of the Pole Artik, and Pole of the Magnes. E A F. the meridian of *London*. L O I. the magneticall meridian for *London*. B. for the place of *London*. H I. the quantitie of the angle of Variation at the ende of the quadrants B H. and B I. C. the interſection



ſection of the two magneticall meridians. C L.and C N. two quadrants of the ſaid magneticall circles,includyng the ark L N.the quantitie of the angle at C. P A M.the Semicircle of a meridian croſſing the magneticall meridian of *Lōdon* in the poinct O.at right angles.

Make out the quadrants I H K. and L N K. ſo ſhall they croſſe them ſelues with the quadrant O A K.at the poinct K.

Now haue you A B C. a ſphericall triangle, two angles whereof and the common contaynyng ſide of them, are giuen. A B C.11.d.$\frac{1}{4}$.the angle of Variation at *London.*

B A C.

B A C.156.d.30'. the complement of the angle D A E.(the difference of the longitudes) to two right angles. And the ſide A B.38.d.28'.the complement of the latitude of *Lōdon.*

And in a ſphericall triangle, not rectangle, whoſe two angles are giuen, and their common contaynyng ſide, the other angle and ſides ſhalbe knowen, by the 31.of the 4.of Regiomontanus.

Wherefore the arke A C. the diſtance of the two Poles ſhalbe giuen, which is the thyng required.

For as the ſine of B H.is to the ſine of H I.ſo is the ſine of B A.to the ſine of A O.and three of them beyng giuen the 4. is found.

90.0'.	*11.15'.*	*38.28'.*	*6.58'.*
B H.	*H I.*	*B A.*	*A O.*

If.100000.giue.19509.——then.62205.giueth.12135.

Now as AK.is to A H.(the ſines I meane) ſo is KO.to OI. but the three firſt are knowen A K.and A H.by their complements, and K O.the quadrant. Therefore the 4.is giuen.

83.2'.	*51.32'.*	*90.0'.*	*52.4.*
K A.	*A H.*	*K O.*	*O I.*

If.99261.giue.78297.——then.100000.giueth.78879.

And as B A.is to B O.(the complement of the arke O I. laſt founde:) ſo is A E. to E M.the quantitie of the angle B A O.

38.28'.	*37.56'.*	*90.0'.*	*81.12.*
A B.	*B O.*	*A E.*	*E M.*

If.62205.giue.61474.——then.100000.giueth.98824.

So hauyng E M.81.d.12'.the quātitie of the angle B A O. I ſubtract the ſame from E G.156.d.30'.the quantitie of the whole angle B A C.reſt M G.75.d.18'.the quantitie of the angle C A O.to the which is equall the oppoſit angle P A D.

And as AP. is to PD. ſo is AK. to KN.

90.0'.	*75.18'.*	*83.2'.*	*73.46'.*
AP.	*PD.*	*AK.*	*KN.*

If. 100000. giue. 96726.—then. 99261. giueth. 96011.

The complement of whiche ark KN. is NL. 16.d.14'. the quantitie of the angle ACB. And as NL. is to NC. ſo is AO. to AC. Wherefore I ſay.

16.14'.	*90.0'.*	*6.58'.*	*25.44'.*
NL.	*NC.*	*AO.*	*AC.*

If. 27954. giue. 100000.—then. 12135. giueth. 43410.

Which is the diſtance of the Pole of the Magnes from the Pole Artik: the thyng that was ſought.

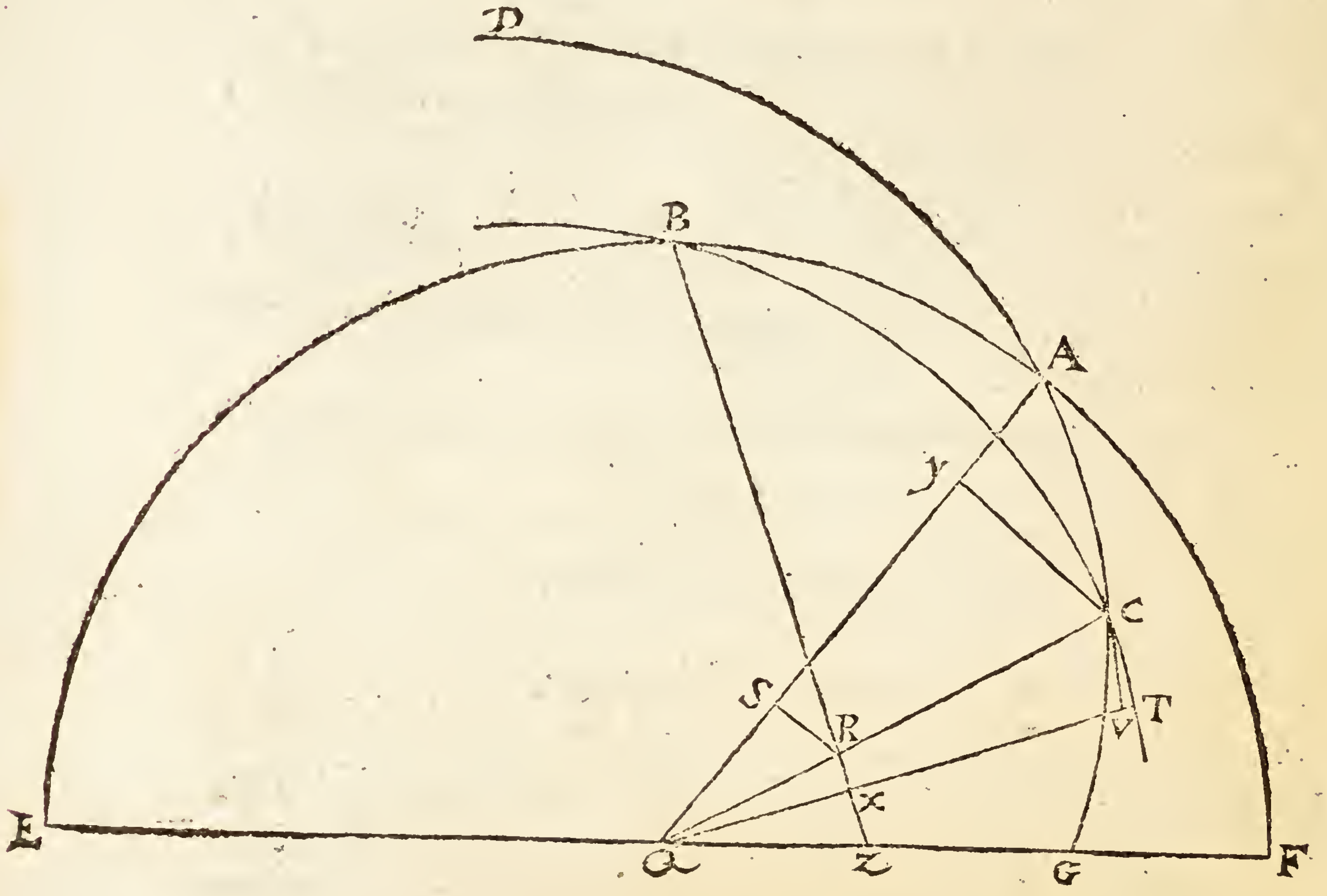
¶Of the poinct Reſpectiue.

¶The ninth Chapter.

Hauyng ſhewed in the former Chapter, vpon the groundes therein ſpecified, the place of the Pole of the Magnes, vppon the ſuperificies of the earth: there reſteth now to bee declared, of the poincte Reſpectiue, where it ſhould be, by the newe propertie founde of the declinyng of the Needle, at this place for London 71.d.50'.

Firſt it is to bee conſidered, that as the Magneticall meridians doe croſſe them ſelues at their Pole, before ſpecified: ſo doe their plaines likewiſe croſſe in a right line, paſſyng by the ſaied Pole, and the centre of the earth. Then producyng a ſtraight line, in the Magneticall plaine of London, declinyng from the plaine of the Horizon 71.d.50'. where the ſame doth croſſe with the former common ſection of the twoo plaines, there by reaſon ſhould the poinct Reſpectiue bee. Whiche interſection I finde to bee from the centre of the earth 1085.

miles (after the rate of 60. to a degree in the Equator, and $3436\frac{4}{11}$. for the Semidiameter of the earth) and the diſtance of the ſame from the axis of the world 471. miles.



LEt the circles be as in the laſt demonſtration. And Q. the centre of the earthe. Then Q A. the axis of the worlde. Q C. the common ſection of the magneticall plaines. B Z. the line of the Needles declination croſſyng the ſaied common ſection at R. whiche is the poinct reſpectiue. Q T. a ſtraight line croſſing BZ at right angles in X. Q R. the diſtance of the poinct reſpectiue from the centre of the earth. R S. the diſtance thereof from the axis. Now as Q V. is to Q C. ſo is Q X. to Q R. But the three firſt are knowne. Q V. the ſeconde right ſine of the ark C T. 9. d. 4′. (the difference of the ark B T. 71. d. 50′. And B C. 62. d. 46′.) Then Q C. the Semidiameter or whole ſine, and Q X. the ſecond right ſine of the ark B T. Wherfore Q R. ſhalbe giuen, by the 4. of the ſixt of *Euclide*.

80.56′. 90.0′. 18.10′.
QV. QC. QX. QR.
If. 98750. giue. 100000.—— then. 31178. giueth. 31572.

So haue I QR. in ſuche parts as the Semidiameter of the earth QC. is 100000. which (being reduced into miles accompting $3436\frac{4}{11}$. for the Semidiameter of the earth) do giue 1084. miles and $\frac{10}{11}$. whiche is the diſtance of the poinct reſpectiue R. from the centre of the earth Q.

Againe, as QC. is to CY. ſo is QR. to RS. wherefore QC. and QR. beyng giuen as before, & CY. the ſine of the ark CA. likewiſe knowne, RS. ſhalbe giuen.

25.44′.
QC. CY. QR. RS.
If. 100000. giue. 43410.—— then. 31572. giueth. 13705.

Which beyng in the parts of the ſines, I reduce into miles as before, and finde the ſame 470. miles and $\frac{10}{11}$. whiche is the diſtance of the poinct reſpectiue R. from the axis of the worlde QA.

¶Of the inconueniences and defects in ſayling, and in deſcription of Countries, cauſed by the Variation of the Cumpas.

¶*The tenth Chapter.*

In all ſea chartes generally, whiche are made without conſideratiõ of the variation, are committed great errours and confuſion. For, either the partes in them contained, are framed to agree in their latitudes by the ſkale thereof, and ſo wreſted from the true courſes that one place beareth from an other by the Cumpas, or els in ſetting the parts to agree in their due courſes, thei haue placed them in falſe latitudes, or abridged, or ouerſtretched the true diſtances betweene them.

In the Marine plattes made for Newfoundlande, the courſe ſette downe from Silly to Cape Raſo is due Weſte, whiche is founde to bee ſo by our common ſailyng Cumpaſſe, whoſe wiers are ſette at $\frac{1}{2}$. a poinct from North to Eaſt, notwithſtandyng Silly beyng in latitude 50.d. little more. Cape Raſo in Newfoundland is founde to bee but in 46.d.$\frac{1}{3}$, which is 3.d.$\frac{2}{3}$. leſſe then the latitude of Silly.

To make a ſhewe of reformation of this error, (cauſed by the Variation and ſettyng of the wiers in the Cumpaſſe) or to giue a light of that difference in latitude, thei haue placed in the plat againſt that coaſte, a newe ſkale of latitude, ſome vppon the line of South and North, and ſome other haue placed the ſame vpon the line of North Northeaſt, & South South-Weſte, (becauſe that poincte of the Cumpaſſe ſheweth the Pole nereſt in that place) and haue furniſhed the degrées thereof, agreeably to the latitude of Cape Raſo: and by that meanes haue had a double ſkale of latitude, one for the Eaſter coſtes, the other for that Weſte. But how farre the ſame hath been from reformyng the error, or giuyng any helpe to Nauigation, you maie eaſely iudge.

Others to auoide that error of the difference in latitude in that voyage and courſe, haue vſed Cumpaſſes whoſe wiers haue been ſette directly vnder the North poincte, and thereby ſailyng Weſte from Silly, haue fallen to the Northwardes of Cape Raſo about 50. leagues, and in latitude nere 49.d.

Some other haue vſed in the ſame voiage to place a blank Flye vpon their ſailyng Cumpaſſe, whiche thei haue remooued from tyme to tyme, as thei haue iudged the variation hath altered, by whiche waie, albeeit thei maie ſeeme to keepe them ſelues neerer the parallell, yet the ſame in Nauigation worketh the greateſt confuſion of all other, and therefore is to bee vtterly aboliſhed.

In our voiages from hence Eaſtwardes to S. Nicolas in Ruſsia, and to the Narue in Liuonia &c. the Marine plattes of the coaſtes are deſcribed by our common ſailyng Cumpas, with conſideration of the variations at diuers places, whereby the true meridians reformedly ſet downe, declining from yͤ parallell meridians of the plat, doe neceſſarily widen Northwardes, and ſtraighten to the Southwardes, contrary to the true forme and nature of meridians. And yet notwithſtandyng, that is the beſt meanes hetherto knowen, to reforme in plat, the errors that els would growe, by the ſtrange variations that waie.

And albeeit theſe plattes ſerue verie well for thoſe Nauigations, yet by meanes of the variations conſidered, the forme of thoſe coaſtes is ſo diſtorted from the right ſhape it ſhould beare, beyng truely deſcribed vpon the Globe or otherwiſe in plaine, accordyng to the true latitude and longitude: That whereas the Narue (beyng in latitude 59.d.¼. and in longitude from the meridian of London 26.d.10′.) ſhould be from S.Nicolas 9.d.40′. in longitude to the Weſt wardes (S.Nicolas beyng in latitude 64.d.35′. and in longitude from London 35.d.50′.) In the ſailyng plat it is brought to bee in the meridian of Colmogorod, (whiche is in latitude 64.d.20′. and in longitude from London 37. d. 45′.) whiche is 1.d.55′. to the Eaſtwardes of the meridian of S.Nicolas.

In the Mediterrancan Sea, and in the coaſtes thereof, where, in great reaſon ſhould be the perfecteſt deſcriptions of the world, for that in thoſe parts haue been the ſeates & abodes of the moſte famous and learned men in all ages, we ſee notwithſtandyng in the Marine plattes of thoſe partes, groſſe errors committed, through want of knowledge of the variation and the vſe thereof; in whiche thei haue not accompted of 3.4.or 5. degrees error in the latitude of places.

But thoſe defectes of the latitudes, haue been verie well reformed, by the famous and learned Gerardus Mercator (whom I honour and eſteeme as the cheef Coſmographer of the world) in his vniuerſal Mapp, which though he haue made with ſailyng lines, and dedicated to the vſe of Seamen, yet for want of conſideration of the Variation, and partly by augmētyng his degrees of latitude towardes the Poles, the ſame is more fitte for ſuche to beholde, as ſtudie in Coſmographie, by readyng aucthours vpon the lande, then to bee vſed in Nauigation at the ſea.

There is alſo in the ſame Vniuerſall Mappe, and likewiſe in all other moderne Mappes of the North partes of Europe, a greate fault, by placyng twoo Wardhouſes diſtant one from the other aboue 20.d. in longitude, whereas in deede thei are but one thyng, and no ſuche diſtance betweene them. This error hath growen by taking Wardhouſe, and the Sea coaſtes, from thence to S. Nicolas, Vaigats and the Ob &c. out of the Mappe of Anthony Ienkinſons trauaile to Boghar and Perſia. In the whiche I placed that border of the Sea coaſte, and for ſome cauſes went no further in that deſcriptiõ then Wardhouſe, whiche is in latitude 70. d. $\frac{1}{3}$. and in longitude from London 29.d. Wherfore to accompliſhe the whole border of that coaſte, he was forced to ſeeke ſome other deſcription to ioine with it, & tooke as appeareth the Mappe of Olaus Magnus of the North countries, wherin he found likewiſe Wardhouſe, but falſly placed, in latitude about 19.d, too muche, and in longitude as muche too little, the which, although he might take to bee the ſame ſpecified in Maiſter Ienkinſons Mappe, yet he was conſtrained to ſeparate thẽ the ſaied diſtance of 20.d. in lõgitude (or to leaue there ſo much ſuperfluous roome) otherwiſe he ſhould haue thruſt the South partes of thoſe cũtries togethers, and confounded the whole deſcription.

And albeeit he had had the entire ſailyng plat, that wee vſe for thoſe partes, yet if he had not knowen the ſecret effect of the Variation in the makyng thereof, he might haue fallen into the like abſurditie or worſe. But of thoſe coaſtes and of the inwarde partes of the countries Ruſſia, Muſcouia &c. I haue made a perfect plat and deſcription, by myne owne experience in ſundrie voiages and trauailes, bothe by Sea and Lande to and fro in thoſe partes, whiche I gaue to her Maieſtie, in Anno 1578.

Beſides theſe and like imperfections proceadyng of the Variation, there is yet an other inconuenience, whiche oftentymes encreaſeth the former errours, and that is, the diuers placyng of the wiers fixed to the Flie of the Cumpaſſe.

This varietie of ſettyng the wiers, hath cauſed greate cōfuſion in Nauigation, and in other accomptes of Sea cauſes, for when it is ſaied, that from ſuche a headlande, to ſuche a place is ſuche a courſe, or at ſuche a place the Moone vppon ſuche a poincte of the Compaſſe maketh the full Sea, it is requiſite to bee demaunded, by what Cumpaſſe the obſeruation was made, whereas if the wiers had not been altered from the North poinct of the Flie, (whiche I wiſhe had neuer been any where) theſe doubtes had been auoided.

It behoueth therefore all men that will make Hydrographicall diſcriptions for the vſe of ſaylyng, to haue ſpeciall regarde of the Cumpas by which their obſeruations are made, and if they collect notes made by ſundry Cumpaſſes of diuers ſetts, they ought to reduce all the varieties vnto ſome one certaine, and to giue notice of the ſame, in their platt: And not to make a confuſed mingle mangle by ioyning together all varieties of obſeruations, notes and reportes, as the Portingales and Spaniards haue done, in compoundyng theſe North parts of the worlde, with their owne diſcoueries, without conſideration of the diuers ſorts of the ſeuerall cumpaſſes by which thei were made.

Alſo it importeth all Maiſters, Pilots and others by what name ſo euer that ſhall giue directions in Nauigatiō, to looke circumſpectly to the ſettyng of the wiers of the Cumpas by whiche they ſhall ſayle, that the ſame Cumpas be correſpondent, to the lines of the Sea Card that they ſhall vſe: that is to ſay, that it be of the ſame ſet for the Variation, that the Cumpas was of, by which the Carde was made.

And ſeyng wee haue in this our Countrey acquainted our ſelues commonly in our obſeruations and Nauigations, with the Cumpas, whoſe wiers are ſet at $\frac{1}{2}$. a poinct from North to Eaſt, I meane in the diſcriptions that I ſhall make, to apply the ſame agreable to the ſaid Cumpas, and would vſe the like without alteration (and alſo the ſtraight lines in Sea Cardes) if I ſhould ſayle rounde about the world to make the deſcription thereof, but alwaies with regarde of the ſeuerall variations of euery place where the ſame ſhould be obſerued.

¶Of the Inſtruments and rules of Nauigation.

¶*The eleuenth Chapter.*

AMongſt the rules and Inſtruments for Nauigation, all ſuche are vaine and to ſmall purpoſe, wherein the true meridian is preſuppoſed to be giuen, by the magneticall Needle, without due conſideration of the variation, for that they are all grounded vppon falſe ſuppoſitions. Hereby it commeth to paſſe that one Michiel Coignet of Antwerp in his New inſtruction (as he termeth it) of the moſt excellent and neceſſary poincts of Nauigation, wherein he ſheweth the makyng and vſe of a Nauticall Hemiſphere, which he preferreth before all other Sea Inſtruments, is very childiſhly abuſed. For where as he pretendeth by it, to giue the eleuation of the Pole and the houre and inſtant of the tyme of the day, by any one obſeruation in any place, beſides that it is of all other that hitherto haue been vſed at Sea, the moſt tedious and vnfit for that purpoſe, it is alſo by reaſon of the variation not conſidered, mere falſe and erronious. For, the true meridian which is the grounde of his purpoſe, is as farre to ſeeke as the thyng he promiſeth to giue by the ſame. The like may be ſaid of al other Inſtruments made vpon the ſame ground whether they ſerue for the Sea or Land.

The ſame Author in the 4. Chapter of his booke, entreting of ſaylyng vpon the poincts of the Cumpas, ſaieth, that in ſailing South or North, he ſhall paſſe by the Poles of the worlde, and keepe vnder one meridian, till he come to the place from whence he firſt departed. And vppon the poincts of Eaſt and Weſt out of the Equinoctiall, he ſhall ſaile vnder a parallell, till he returne to the place from whence he went. But in ſaylyng vppon the poinct of Northeaſt, he ſhall deſcribe a ſpirall line inclynyng by little and little towardes the Pole, as in his demonſtration thereof in the ſame Chapter appeareth. But for want of due conſideration of the variation, his rules, reaſons and demonſtrations, and ſuche others hitherto giuen for like purpoſes, are friuolous and falſe.

For if he direct his ſaylyng by the Cumpas (as of neceſſitie he muſt, beyng the onely Inſtrument for that purpoſe) it is manifeſt, that whether he ſayle North or South, Eaſt or Weſt, or by what other poinct ſo euer, the Cumpas not reſpectyng alwaies the Pole of the world, as he ſuppoſeth, but ſome other poinct or poincts diſtant from the ſame, ſhall leade hym accordyngly, whereby he ſhall neither keepe vnder one meridian, nor vnder one parallell of latitude, neither make ſuch a ſpirall line to the Pole of the world, as he demōſtrateth. His fault in ſettyng downe thoſe rules is ſo muche the greater, in that he acknowledgeth in the Chapter next before the variation at Antwerp, to bee about 9.d. from North to Eaſt accordyng to Mercators poſition, of the Magneticall Pole, which he alſo confirmeth by his owne experience.

But it ſeemeth he hath followed, that excellent Mathematician Petrus Nonius, eſpecially concernyng the ſaylyng vppon the poincts of Eaſt and Weſt. For he, in his firſt booke of the rules and Inſtruments of Nauigation, enforceth hym ſelf to proue and demonſtrate, that in ſaylyng Eaſt or Weſt, out of the Equinoctiall, the courſe is performed by peeces of great circles, and yet deſcribeth a parallell. But how that may ſtande with the principles of Geometry, I referre the iudgement to the expert Mathematicians, for it is like as a circle ſhould be made of ſtraight lines, which is impoſſible.

It appeareth in the diſcourſe that he hath made of thoſe matters, that he had not a right iudgement of the nature of the Cumpas in ſaylyng (admitting the ſame to ſhew the Pole without Variation) for if he had, he would neuer haue entred into ſuche a Labyrinth as he did. But he thought it a great abſurditie that the Cumpas in euery Horizon ſhould ſhewe the meridian and Poles of the world by the poincts of South and North, and by the poincts of Eaſt and Weſt to ſhewe in the Horizon the verticall and Equinoctiall Eaſt and Weſt (being a great circle) and yet in ſaylyng Eaſt or Weſt, except in the Equinoctiall, it ſhould performe but a parallell.

But it is to be underſtood, that albeit the poincts, or lynes of the Cumpas doe alwaies in euery Horizon repreſent great circles in the Heauens, the points of South and North the meridian, and the poincts of Eaſt and Weſt the verticall circle of Eaſt and Weſt, eche croſſyng other at right angles, and likewiſe of the other poincts, (The reaſon whereof is, becauſe the Cumpas lieth euery where leuell with the Horizon, ſo as a perpendicular line deſcendyng from the centre thereof at right angles with the plaine of the ſame, will alwaies fall upon the centre of the earth, and conſequently be the Semidiameter of a great circle.) So that where ſo euer the Cumpas be caried, theſe circles are ſuppoſed to be caried about with it, and the view of euery thyng in the Horizon repreſented by the poincts thereof, is likewiſe in great circles: Yet in ſaylyng by the Cumpas, the poincts of South and North onely, deſcribe great circles generally, which are the meridians, & the points of Eaſt and Weſt, deſcribe a great circle in the Equinoctiall onely: in all other places out of the Equinoctiall, they deſcribe but parallells. And the ſaylyng uppon any other poinct of the Cumpas, from any place, deſcribeth a ſpirall line, accordyng to the angle it maketh with the meridian. And hereby in ſaylyng upō the poincts of Eaſt or Weſt, out of the Equinoctiall, (the North poinct alwaies reſpectyng the Pole) the courſe performeth a parallell, accordyng to the diſtance of the centre of the Cumpas from the Pole. The maner thereof you may perceiue by faſtnyng a ſmall threed or Virginall wier at the Pole of a Globe, or centre of a circle, which ſhall repreſent a moueable meridian to bee caried about the Globe or circle, and fixe uppon the ſame, a ſmall Flye of a Cumpas, ſo as the line of South and North be anſwerable to the threed or wier, and the North poinct thereby alwaies reſpect the North Pole: then in turnyng the threed about the Globe or circle, vpon the Pole or center, if the center of the Flye bee out of the Equinoctiall (between it and the Pole) albeit the points of Eaſt and Weſt croſſyng the ſame line and moueable meridian at right angles, doe ſhewe the verticall Eaſt and Weſt vpon the Globe, which is a great circle, yet in caryng the ſame Flye vpon the threed or moueable meridian, about the Pole or center, you ſhall by the center of the ſame Flye, deſcribe but a parallell, accordyng to the diſtance thereof from the Pole of the Globe, or center of yͤ circle, not vnlike the circular motiõ of a Horſe drawyng in a mill, who though he looke forth ſtraight in a right line, yet beyng faſtned to the beame of the mill, is forced to make his courſe in a circle, whoſe Semidiameter is the lẽgth of the beame contayned betweene the Horſe, and the centre of the mill, or milpoſt.

And as in the Equinoctiall, the line of South and North in the Cumpas (by ſuppoſition repreſenting the meridian) is parallell to the Axis of the earth (which is the common ſection of all the meridian plaines) and the line of Eaſt and Weſt croſſyng the ſame Axis at right angles, repreſenteth the verticall Eaſt and Weſt, which is the Equinoctiall, imaginyng to deſcende from the centre of the Cumpas a line, to fall perpendicularly, and at right angles with the Axis of the worlde (whiche ſhall bee at the centre of the earth) and in ſaylyng Eaſt or Weſt by the Cumpas, the imagined perpendicular line being caried about with the ſame (makyng alwaies right angles with the Axis) ſhal deſcribe the plaine of the Equinoctiall equidiſtant from the Poles of the world, and at right angles with the Axis, and the poinct of the ſame line at the centre of the Cumpas, the circumference of the Equinoctiall, vppon the ſuperficies of the Sea: So beyng from the Equinoctiall on either ſide, imaginyng the line of South, & North in your Cumpas to repreſent alwaies the Axis of the world, and to lye parallell with it, the line of Eaſt and Weſt muſt croſſe the ſame Axis alwaies, at right angles: and ſuppoſing a line to fall from the centre of your Cumpas to the Axis of the world, makyng right angles with the ſame Axis. In ſaylyng Eaſt or Weſt, that imagined line beeyng caried about with the Cumpas (alwaies at right angles with the Axis) ſhall deſcribe the plaine of a parallell, equidiſtant to the plaine of the Equinoctiall, and the poinct thereof at the centre of the Cumpas, the circumference of the parallell vppon the ſuperficies of the Sea: which parallell ſhould be repreſented by the poincts of Eaſt and Weſt of the Cumpas, if the line of South and North of the ſame were parallell to the Axis of the earth, as was ſuppoſed: but it is not. And therfore as they decline one from the other, ſo doeth the verticall circle of Eaſt and Weſt ſhewed by the Cumpas, decline from the parallel circle euery where.

The angle of whiche declination, is alwaies equall to the latitude of the place, or diſtance of the parallell from the Equinoctiall.

But as I haue already ſufficiently declared, the Cumpas ſheweth not alwaies the Pole of the worlde, but varieth from the ſame diuerſly, and in ſayling deſcribeth circles accordyngly. Whiche thyng if Petrus Nonius and the reſt that haue written of Nauigation, had ioyntly conſidered in the tractation of their rules and Inſtruments, then might they haue been more auaileable to the vſe of Nauigation, but they perceiuyng the difficultie of the thyng, and that if they had dealt therewith, it would haue vtterly ouerwhelmed their former plauſible conceits, with Pedro de Medina (who as it appeareth hauyng ſome ſmall ſuſpition of the matter, reaſoneth very clerkly, that it is not neceſſary that ſuch an abſurdity as the Variation, ſhould be admitted in ſuch an excellent art as Nauigation is) they haue all thought beſt to paſſe it ouer with ſilence. But I hope ſuche as intende hereafter to write of Nauigation, will either frame their rules, precepts, and Inſtruments, with regarde of the Variation, as herein I haue ſhewed, or els eaſe them ſelues of that trauaile, for as good none as vnprofitable.

¶Of the application of the Variation to the vſe of Nauigation.

¶The twelfth Chapter.

Vpon the Hypotheſis of the Pole of the Magnes on the ſuperficies of the earth, and the poinct Reſpectiue in the body thereof, accordyng to the former calculatiõs, might be inferred many pleaſant concluſions, both for the longitude and latitude of places.

But touchyng the poinct Reſpectiue by the declinyng of the Needle, ſeeyng this is the firſt and onely experiment that hath been made of it, I can not inferr any furder matter thereof, then that whiche I haue already ſet downe, vntill by obſeruations in other places, we finde how it will holde.

And as for the Variation, if it were generally regular and certaine, as in ſome part it ſeemeth to be: (that is to ſay, from hence Weſtwardes to Meta Incognita, Newfoundland, Florida, and that part of the coaſt of America) then might there be giuen by it generall rules moſt certaine and commodious for the vſe of Nauigation.

And by the ſame Hypotheſis of the Pole of the Magnes at 25.44′. from the Pole of the world, the greateſt variation of the Needle in the Equinoctiall, ſhould be (at 90.d. of Longitude) 25.44′. from North to Eaſt. And conſequently the greateſt variation in the parallell of 70.d. ſhould bee (at the longitude of 128.d.51′.) from North to Eaſt 81.d.14′. And in the meridian of 180.d. of longitude between the two Poles, (the Pole Artik I meane, and the ſuppoſed Pole of the Magnes,) there ſhould the North poinct of the Needle or Cumpas reſpecting his own Pole, ſhew the South, and the South point, the North Pole of the worlde.

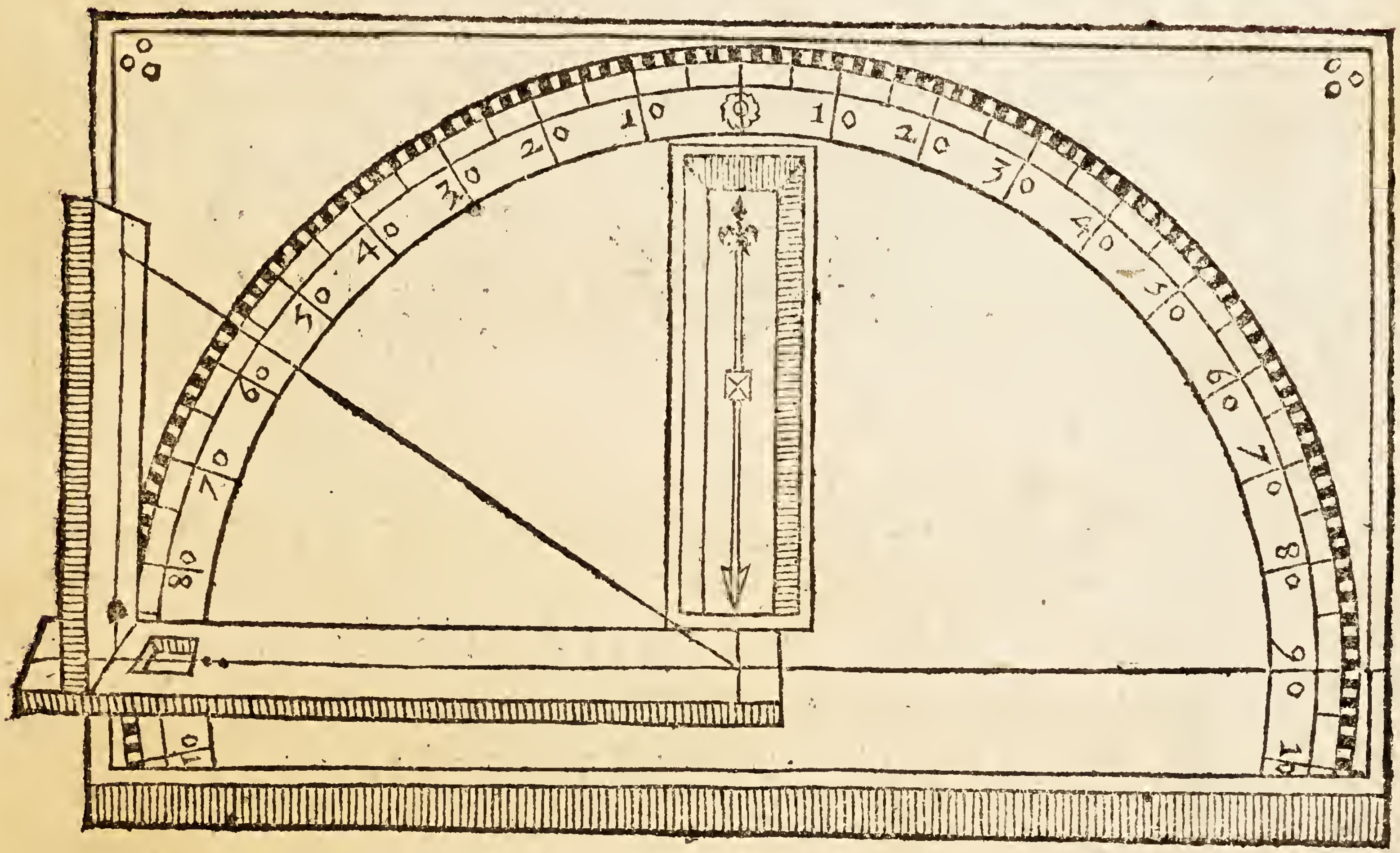
But in my trauelles to the Northeſt parts, I haue found this poſition of the magneticall Pole clene reuerſed: for where as the angle of Variation from hence Eaſtwardes in the parallell of 70.d.ſhould encreaſe and growe wider, till it came to 81.d.14′.from North to Eaſt as before. At the Iland Vaigats beyng in longitude from London 58.d.and in the ſame parallell of 70.d.where, by the Hypotheſis, the variation ſhould be 49.d.22′.from North to Eaſt, I finde the Needle to vary 7.d.from North to Weſt. And the like effect I haue found by diuers obſeruations in ſundry other places of the Eaſt partes. Whiche obſeruations with many more that I haue cauſed to bee made, and dayly procure to be done in diuers other Countries, I reſerue, with intent (if it bee poſſible) to finde ſome Hypotheſis for the ſaluyng of this apparant confuſed irregularitie.

At Ratiſbona or Regenſburg in Bauaria, beyng in latitude 48.d.52′.and in longitude 36.d.20′.where, by the former poſition of the magneticall Pole at 25.d.44′.the Variation ſhould be 16.d.44′.from North to Eaſt. Gerardus Mercator found the ſame to be onely 11.¾.as I gather by his placyng of the magneticall Pole at 16.d.22′.from the Pole Artik vpon his obſeruation made at that place: whiche confirmeth the retrograde qualitie in the Variation from hence Eaſtwardes, as aforeſaid.

Whiche ſtraunge varietie, I haue here plainly propoſed, to the ende that the learned ſorte might conſider thereof, and ſharpnyng their wits, ſee what probable cauſes and grounds they can aſſigne for the ſame. For, conſideryng it remayneth alwaies conſtant without alteration in euery ſeuerall place, there is hope it may be reduced into method and rule.

As for that Weſtwardes, becauſe it carieth proportion, and hath ſome apparant regularitie, I will apply the ſame to the generall commoditie of all ſuche as ſhall trauaile that waies: which if I ſhould here particularly decipher, it would require a volume, whereby (contrary to my firſt intent) I ſhould farre exceede the bounds of an addition, I will therefore abridge it to a Hydrographicall Plat, wherein all ſuch errors and defects as haue been hitherto vſed, ſhalbe reformed, which ſhall be eaſy for the meaneſt capacities to conceiue, and ſerue more effectually in vſe, then if I ſhould haue expreſſed the ſame by multitudes of rules in wrytyng. Therefore for this matter I referre you to the ſame, the whiche you ſhall looke for very ſhortly.

¶ *A new Inſtrument for* the Variation.



Becauſe I haue found ſome imperfections in the firſt Inſtrument for the Variation (whiche notwithſtandyng doeth farre excell the Cumpaſſes of Variation heretofore vſed for that purpoſe) I haue here ſet downe the forme of a newe Inſtrument, wherein all ſcruple of doutes and defects that might growe by the other is quite auoyded. Whiche beyng once exactly placed with the Needle vpon the line of South and North, will ſerue without remouyng for a whole daies obſeruation, the Index onely beyng caried about with

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Of the Variation

with the Sunne, to giue the degrees of Azimuth vppon the Inſtrument by the ſhadowe of the line thereof, and is otherwiſe to be vſed accordyng to the preſcript rules of the former Inſtrument.

Theſe Inſtruments are made by Robert Norman, and may be had at his houſe in Ratclif.

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